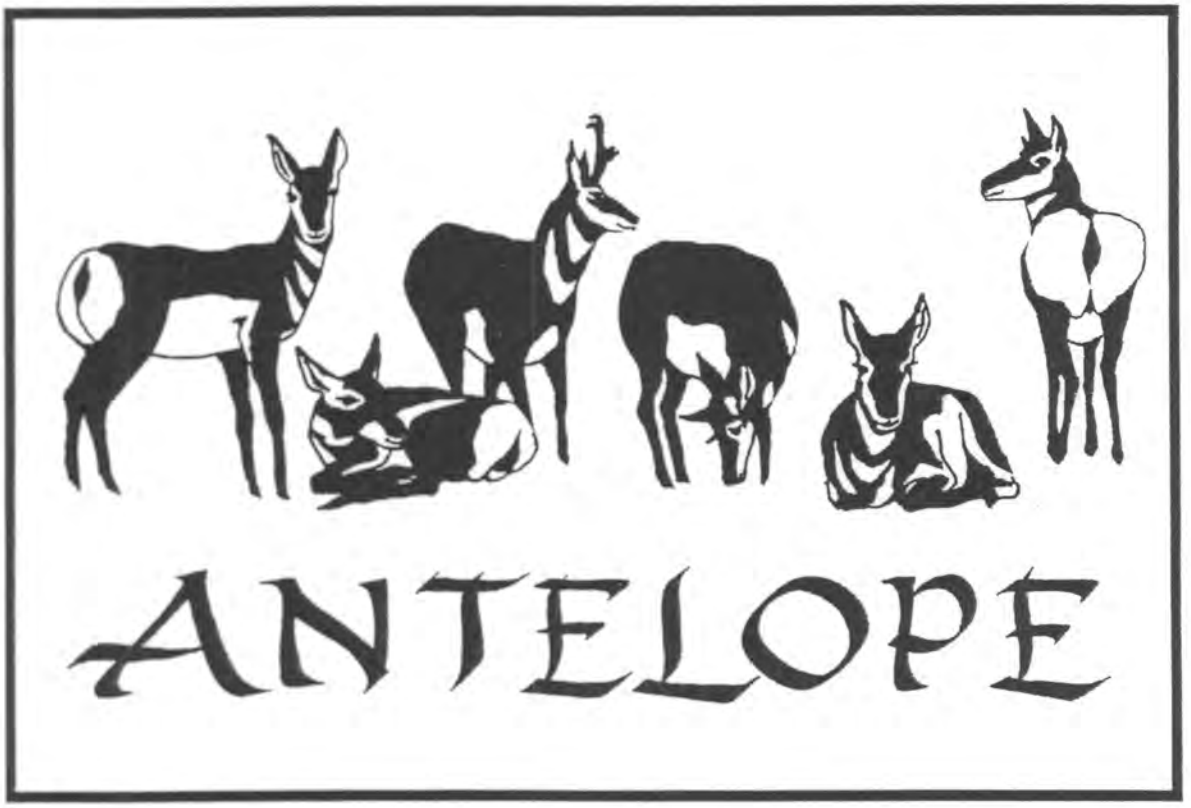
Proceedings of the Fourteenth Biennial

PRONGHORN ANTELOPE WORKSHOP



May 22-24, 1990
SilverCreek, Colorado

PROCEEDINGS

of the

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Chairman

Thomas M. Pojar

PREFACE

The Colorado Division of Wildlife hosted the 14th Pronghorn Antelope Workshop at SilverCreek, Colorado during May 22-24, 1990. Forty-five persons attended the workshop. There were 10 states represented by 33 individuals, 3 federal agencies represented by 5 persons, 3 universities by 5 persons, 1 representative from the Apache Indian Tribe and 1 person from a private consulting firm. Unfortunately, there were no representatives from Canada or Mexico.

The purpose of this workshop is to foster the exchange of ideas among pronghorn managers and to offer a forum for research findings related to the biology and management of pronghorn antelope. The ultimate objective is to promote better management of the pronghorn antelope resource. To this end, efforts continue to be made to update and expand the Management Guidelines. Recent advances in capture and translocation techniques were addressed in the last 2 workshops and culminated in the most recent update of the topic in these proceedings. In addition, of the Management Guidelines, including all sequels, is proposed for completion by next workshop. Major topics to be covered are: capture techniques, census, range improvements, affects of energy development and habitat evaluation.

Ten states provided the workshop with pronghorn population and management status reports. Thirteen technical papers were presented. The discussion after the papers was not recorded. The minutes of the business meeting are based on written notes taken by the chairman. A field trip to nearby rangelands was conducted to discuss recently occupied pronghorn habitat.

Wyoming will host the 15th biennial workshop in 1992.

Editing of these Proceedings was limited to attempts at consistent format, correct spelling (using a computerized spell checker), and correction of grammatical and punctuation errors. Some of the papers had to be retyped, which exposed them to typographical errors. With the help of Lenora Lovett, Nancy McEwen and Jim Miller most of these were detected and corrected. I take full responsibility for any that may remain. Jim Yoakum and Bart O'Gara were kind enough to review a preliminary draft of this entire document. To them I extend my appreciation.

This publication is dedicated to the memory of Bob Watts. He was a significant contributor to this workshop and to the advancement of knowledge of pronghorn antelope. He will be remembered and missed.

Thomas M. Pojar, Workshop Chairman

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SUMMARY OF PRONGHORN WORKSHOPS HELD TO DATE

Meeting Dates and Locations	Number Attending	Chairman	Host Agency
April 14-16, 1965 Santa Fe, NM	18	W. Huey	New Mexico Dep. of Fish and Game
Feb 16-17, 1966 Denver, CO	32	G.D. Bear	Colorado Game, Fish and Parks Dep.
Feb 5-6, 1968 Casper, WY	97	J.L. Newman	Wyoming Game & Fish Commission
Jan 27-28, 1970 Scottsbluff, NE	85	K.I. Menzel	Nebraska Game & Parks Commission
June 19-22, 1972 Billings, MT	85	H.O. Compton	Montana Fish & Game Dep.
Feb 19-21, 1974 Salt Lake City, UT	52	D.M. Beale	Utah Division of Wildlife Resources
Feb 24-26, 1976 Twin Falls, ID	68	R. Autenreith	Idaho Dep. of Fish and Game
May 2-4, 1978 Jasper, Alberta	84	M.W. Barrett	Alberta Fish & Wildlife Division
April 8-10, 1980 Rio Rico, AZ	64	J.S. Phelps	Arizona Game & Fish Dep.
April 5-7, 1982 Dickinson, ND	69	J.V. McKenzie	North Dakota Game & Fish Dep.
April 10-12, 1984 Corpus Cristi, TX	45	C.K. Winkler	Texas Parks & Wildlife Dep.
March 11-13, 1986 Reno, NV	43	M. Hess	Nevada Dep. of Wildlife
May 31-Jun 2, 1988 Hart Mt., OR	43	D. Eastman	Oregon Dep. of Fish & Wildlife
May 22-24, 1990 SilverCreek, CO	45	T.M. Pojar	Colorado Division of Wildlife

PROVINCIAL AND STATE

STATUS REPORTS

ARIZONA ANTELOPE STATUS REPORT - 1990

Raymond Lee, Arizona Game and Fish Department, Phoenix

Population estimates

Arizona's pronghorn antelope population is composed of three sub-species; Antilocapra americana americana, A. a. mexicana, and A. a. sonoriensis. During the survey period, which occurs in July and August, prior to the hunt and after most fawning mortality, Arizona's antelope population is approximately 12,100; 11,250 americana, 750 mexicana, and 100 sonoriensis. The Game Management Units with the largest populations are Units 5B, 10, and 19B; these units contain nearly 33% of the total population.

Survey

Pronghorn in Arizona are surveyed primarily from fixed-wing aircraft (Piper Super Cub, or STOL Cessna 182 or 206). A total of 7,138 americana were surveyed in 1989, resulting in buck:doe:fawn ratios of 31:100:23; this is close to the 15-year average of 32:100:33 (Fig. 1). A total of 376 mexicana were surveyed, resulting in ratios of 52:100:19. Fawn survival was below average throughout the state, presumably due to the drought conditions. Sonoriensis are not hunted, being listed as an endangered species, and are not routinely surveyed. These animals were surveyed in Mexico this year. In 25 hours of fixed-wing survey effort, 33 antelope were observed. Further survey and radio-telemetry work in cooperation with Mexico is planned for the future.

Harvest

In 1989, a total of 608 antelope were harvested. New harvest and hunter success ratios were set by archers (55 and 12%) and by muzzleloaders (125 and 58%). Application rates for the three weapon types vary considerably. When archery hunting first began in 1974, only 16 hunters applied for the 50 permits available. In 1989, 564 archers applied for 508 permits (1.1 applicants per permit). Muzzleloader permits were oversubscribed by 1,684 applicants for 222 permits (7.6 applicants per permit) and the center fire rifle hunters' application rate was 7,818 for 572 permits (13.7 applicants per permit). These application rates led to minor adjustments in the 1990 permit levels to more accurately allocate permits by demand (Fig. 2). Additional 1989 harvest information is shown below and in Figure 3:

Weapon	Permits	Hunters	Days Afield	Harvest	% Success
CFR	572	561	1199	428	76
Mzl	222	216	520	125	58
Arch	508	475	2565	55	12

One of the most significant results of Arizona's antelope harvest is in the Boone and Crockett scores. Numerous trophies in excess of 90 points have been reported. Unofficially, Arizona has now produced 12 of the top 20 scores.

Management Plans, Strategic Plans, and Guidelines

The Arizona Game and Fish Department provides each of its Wildlife Managers with an antelope species management plan. This document gives guidance on how to survey, make hunt recommendations, fence, supplemental feed, etc. their antelope populations. Hunt guidelines are annual guides, reflecting the political climate, for setting season dates and permit numbers. In 1990, season dates will be 8/26 - 9/8 for archers, with stratified seasons for firearms hunters of 9/23 - 9/26 and 9/30 - 10/3. The strategic plans tell where the Department is going in antelope management and identifies hunting strategies. Antelope are managed under basic, alternative, or vulnerable species criteria. The prime criterium is for post-hunt buck to doe ratios. Basic management calls for 25-30:100, with 30-40:100 for alternative, and 35+:100 for vulnerable species. Other criteria deal with hunter density, ranging from 1 permit per square mile to 1/2 per square mile, and percentage of the yearly buck recruitment, ranging from 60 to 40%. New Strategic Plans for antelope will be developed this summer.

Transplants

Arizona has engaged in a fairly active antelope transplant program since its first release with Nevada antelope in 1924. Recently, Arizona has had the good fortune of having the money and excess bighorn sheep to initiate trades with several western states for pronghorn antelope. Usually, we are helping remove depredating animals, however, we have been "in the market" for the mexicana sub-species to repopulate historic range. Recent transplants have been canceled due to drought-induced habitat limitations.

Special Studies

A Sonoran pronghorn study has been underway for several years. Primarily, the research is concerned with habitat use, fawning rates, and movement patterns. A total of ten antelope have been fitted with transmitters for this work. The animals were captured using a net-gun.

A report on the effectiveness of aerial coyote control has been produced. The Department is engaged in an active program to aerially gun transplant sites and units where the fawn crop falls below 20:100 for 2 consecutive years.

A new research program was recently started. The objectives of this project are to determine the areas, locations, habitat characteristics, and land ownership or seasonal pronghorn antelope habitats throughout Arizona.

Special Permits

The Department is in the business of auctioning or raffling special permits for fund raising purposes. Since 1984, over $1,000,000 has been raised through this program. The most successful have been for bighorn sheep ($85,000 for a permit) and elk ($53,000 for a permit). For several years special antelope permits were distributed, now resulting in approximately $12,500 per permit. These funds are earmarked for antelope management and have been expended on the antelope transplant program and the accompanying coyote control effort.

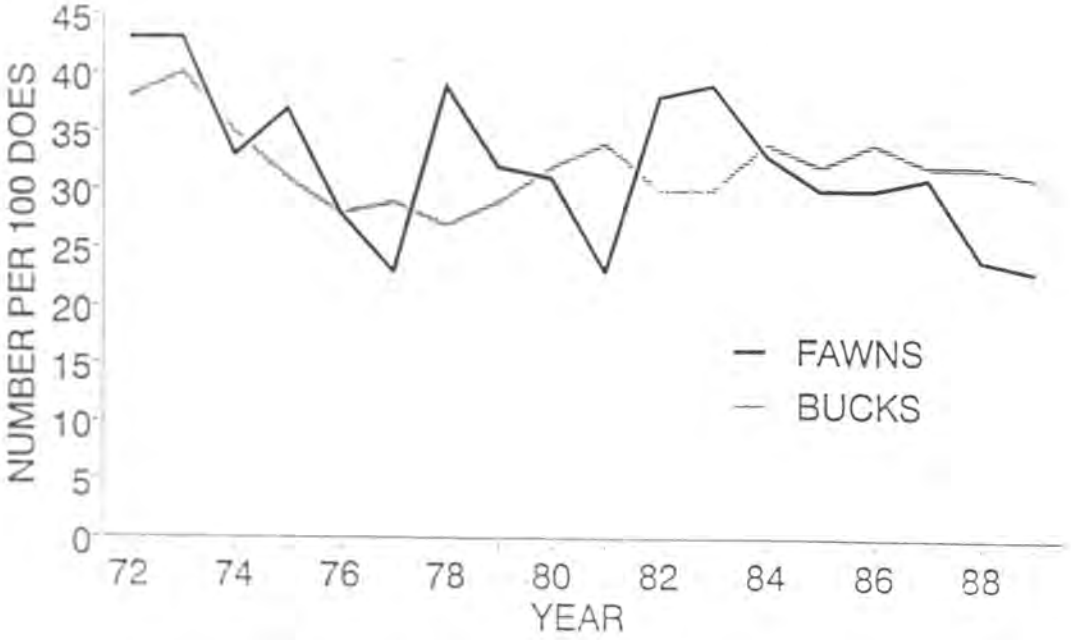


Figure 1. Statewide trends of buck:doe:fawn ratios for 1972 through 1989.

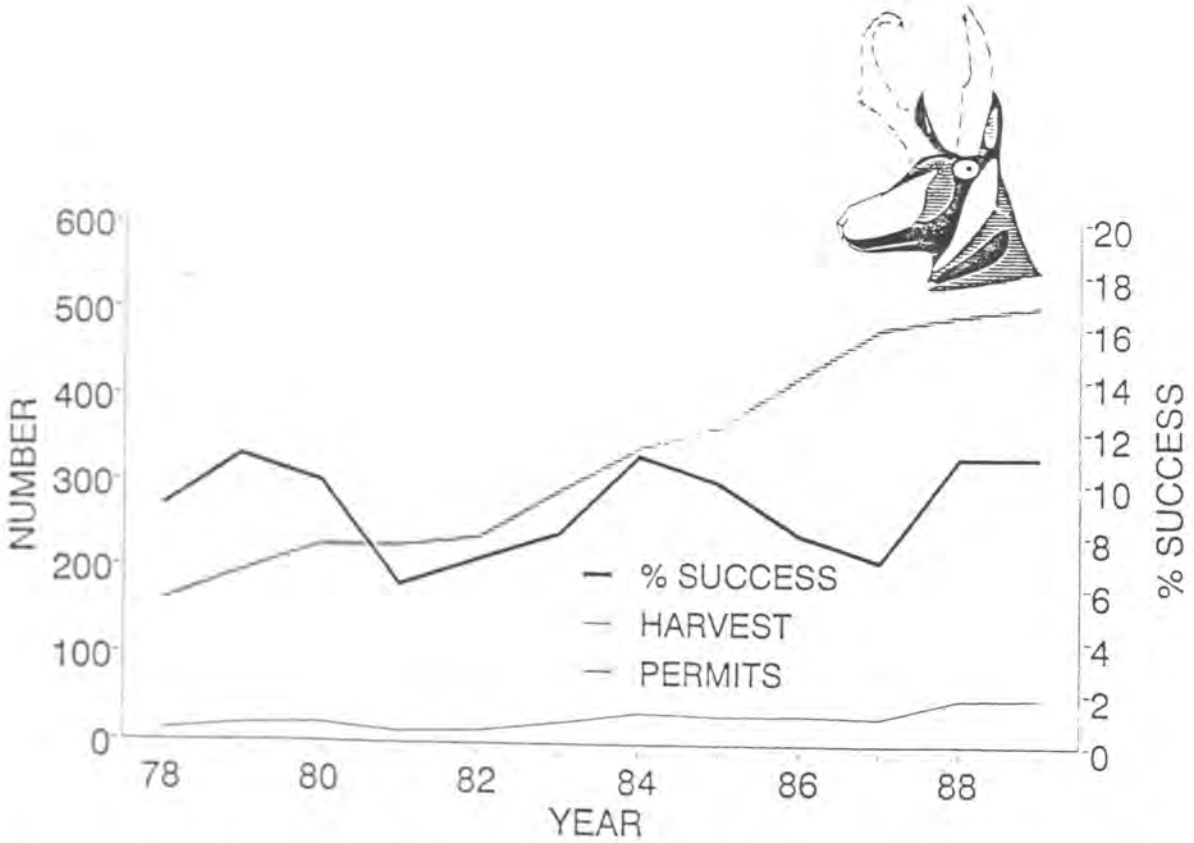


Figure 2. Statewide trend in archery permit numbers, harvest and percent success for 1978 through 1989.

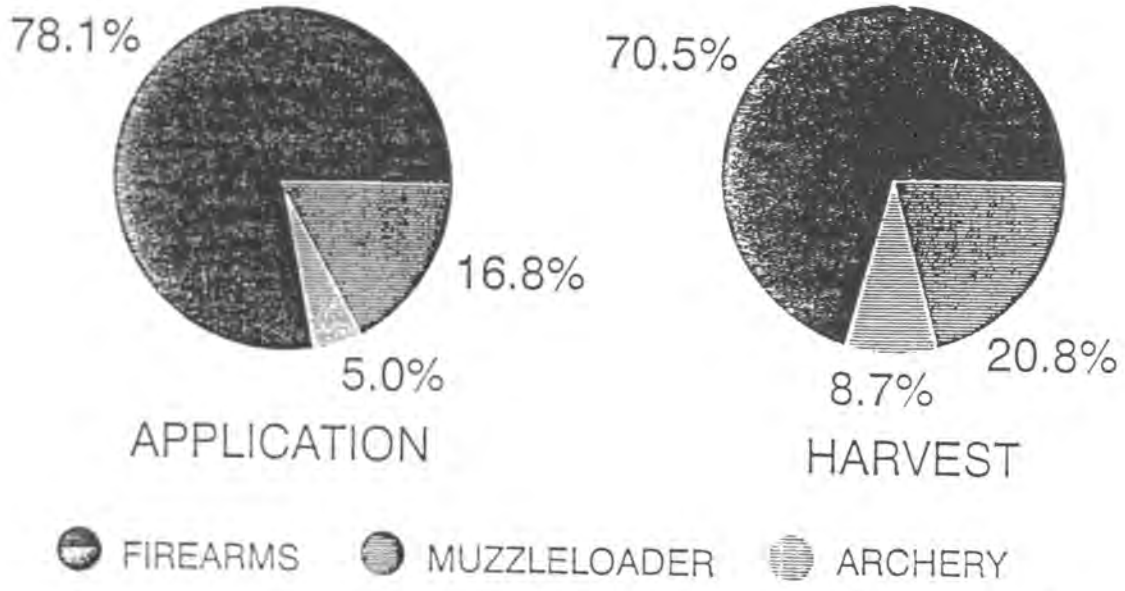


Figure 3. Percentage of applicants and harvest by 3 weapon types.

COLORADO PRONGHORN ANTELOPE STATUS REPORT - 1990

André C. Duvall, Colorado Division of Wildlife, Fort Collins

POPULATION

Colorado's pronghorn antelope prehunt population is approximately 58,000 animals. The posthunt population is approximately 47,000 animals. The population in all parts of the state appears to be stable with slight local increases. The long-term posthunt population objective is 52,390.

Survey methods include pre and posthunt aerial flights using both fixed-wing aircraft and helicopters. Surveys are done for production counts, age and sex ratios and total population. Kinds of counts are random block quadrats, line transect and continuous strips. Prehunt and preseason ground surveys are done with random quadrats for ratios, production and ground truthing the aerial counts. Most Game Management Units are counted in some way each year or scheduled every other year.

Population models are done for each Data Analysis Unit (a collection of some herd Game Management Units) utilizing POP-II, Ver. 6.8 programs.

HERD STRUCTURE

Prehunt herd sex ratios structures in the state for bucks range from 24 to 62 bucks per 100 does. Posthunt ratios range from 12 to 54 bucks per 100 does.

Prehunt production figures range from 31 to 73 young per 100 does. Posthunt production figures range from 13 to 72 young per 100 does.

HARVEST/HUNTING REGULATION

In 1989 there were 11,456 hunters for all antelope seasons. The total estimated harvest for all seasons and all methods was 8,532 animals including: 4,931 bucks, 3,369 does, and 232 fawns.

The regular rifle hunting season (which includes muzzleloading) is 7 days in length. In the northern one-half of the state, the dates for 1990 are: September 29-October 5. The dates for the southern one-half of the state are October 6-October 12, 1990. The regular archery season is August 15-September 25, 1990. There are special dates for "wildlife ranching" hunts, and there may be special late big game damage hunting seasons in a particular year.

RANGE CONDITIONS

There are no special changes or modifications at this time. No major development impacts are going on at this time since oil exploration is slow and the breaking out of prairie land for winter wheat has abated considerably.

DISEASES

There are no currently known outbreaks of diseases in the state at this time. Normal monitoring continues annually for diseases such as bluetongue, brucellosis and leptospirosis. Recently, monitoring for chlamydia was instituted.

MOVEMENTS AND DISTRIBUTION

Management and research movement studies were recently done on the interstate herds between Colorado and Wyoming. Cooperation between the two states showed us hunting and modeling the same herds as though they were separate and distinct populations.

Pronghorn have recently established a small resident population in Middle Park, located in northcentral Colorado approximately 60 miles south of the Wyoming border.

UNIQUE INCIDENCES

Four-horned pronghorn have been reported on the Colorado/Wyoming border, as have albino pronghorn.

RESEARCH

Current research includes: The Dynamics of Pioneering Pronghorn in the Middle Park Area, researched by Tom Pojar. This study monitored the seasonal and annual distribution of the pronghorn and associated the seasonal and annual home ranges with specific habitat types. Proposed research includes a study on the effects of female mate choice on male pronghorn reproductive success.

One suggested research need was recently pointed out: a sociologic study as to why, when we have definitive research data on such topics as the spread of bindweed, winter wheat damage, and diet overlap with domestic stock, etc., landowners refuse to believe the results.

IDAHO ANTELOPE STATUS REPORT - 1990

Louis J. Nelson, Idaho Fish and Game, Boise

POPULATION

There are approximately 22,000 antelope in Idaho. This estimate is based on limited census work across the state. The antelope population in some units has been estimated using the aerial line transect method developed in Wyoming.

The antelope populations across the state are increasing. Antelope populations are also increasing in areas which had only incidental reports of antelope in prior years. Winter loss of antelope in some units in central Idaho was above average during the 1988-89 winter.

The high antelope populations and drought conditions, which resulted in low native forage production, have resulted in some severe agricultural depredation problems. The most severe problems have been on irrigated alfalfa (starting in early August) and on stacked hay (in the winter). These depredation problems have been centered in a few localized areas.

HERD STRUCTURE

The buck:doe and fawn:doe ratios vary widely around the state. In many units, buck harvest has significantly decreased the buck:doe ratios. In units with lower harvest levels, the buck:doe ratios are higher. Antelope herd composition estimates are derived from helicopter surveys conducted in early August. Relatively little herd composition survey work has been done in the last few years.

HARVEST REGULATIONS

Idaho is now in the process of developing a new five-year plan for antelope management. A hunter opinion survey conducted by the University of Idaho found that deer, elk and bird hunters were looking for a variety of specific hunting experiences. Antelope hunters were not surveyed, but the general pattern of hunting experiences desired were consistent among all three groups of surveyed hunters. The proposed plan (released for public review) establishes three groups of units that differ in the type of hunting experience offered and the potential for antelope depredation problems. The units are grouped on the basis of hunter density, antelope population size and composition, road density, agricultural development, environmental conditions and distance to human population centers.

In the first group, hunting pressure is light or dispersed and generally occurs in areas of high aesthetic appeal away from major human population centers. Roads often traverse rough terrain, are of poor quality and are limited in number. Antelope numbers may be high or low, but the opportunity to harvest a mature buck is high.

In the second group, a full range of experiences can be obtained by hunters. Antelope numbers are high, which supports high hunter density, high harvest and high success rates. Doe- and fawn-only hunts are offered in these units to control the population size (if necessary). Hunters can find a wide variety of hunting experiences at different locations within these units.

The third group is characterized by high hunter density, high antelope populations, agricultural development, high road densities and motorized vehicle use. The availability of antelope bucks is limited. Antelope depredation problems often dictate hunting season structure and harvest levels.

The proposed hunting season structure is for:

Archery -Most Units -Unlimited Tags	August 30-September 18
Any Antelope -Limited Permits	September 15-October 24
Doe/Fawn Antelope -Limited Tags	October 5-October 24
Muzzleloader/Shotgun -Limited Permits -Only a Few Units	September 25-October 24

The number of permits available in each unit will be based on the size of the antelope population and the objectives of the group of units in which it is included. These season dates will allow sportsmen the opportunity to hunt sage grouse in addition to antelope during the first three weeks of any antelope hunt. There will also be some special depredation hunts in areas with significant damage problems during mid-August.

RESEARCH

There is no research on antelope in Idaho at this time. The most pressing need in Idaho is for a census technique that could be utilized in a variety of habitats, antelope densities, antelope group sizes, and provide an estimate of herd composition. An efficient method of estimating antelope damage to standing crops would also be very useful.

KANSAS ANTELOPE STATUS REPORT - 1990

Keith Sexson, Big Game Program Coordinator, Kansas Wildlife and Parks

POPULATION STATUS

Aerial counts using fixed-wing aircraft are conducted in July (production counts) and January (winter counts). Counts in January, 1990, produced estimated population levels of 1,000 to 1,200 antelope in the major westcentral Kansas antelope range. There is an additional estimated combined total of 300 animals in scattered locations (southwest, southcentral, and eastcentral Kansas).

July, 1989, production counts in the major range provided a ratio of 12 bucks:100 does:50 fawns. This compares to 53 bucks:100 does:76 fawns in 1988.

ARCHERY SEASON

The 1989 archery antelope season was held September 23-October 1. Archery hunting is open in portions of 10 counties in extreme westcentral Kansas. A total of 75 permits was issued; 150 permits were available. Hunter questionnaires are mailed with all permits. Fifty-four active archers reported harvesting 16 antelope (13 bucks and 3 doe/fawn) for 29.6% success. The 1989 season provided 213 man days of hunting recreation. In 1988, 53 active archers harvested 6 animals for 11.3% success.

FIREARM SEASON

Kansas' sixteenth firearms antelope season was October 7-9, 1989. A total of 260 permits was available in four hunting units. All permits were issued and 247 hunters indicated they participated in the hunt. These active hunters spent 306 mandays hunting and harvested 217 antelope for 87.8% success. The harvest consisted of 176 bucks and 41 does/fawns. This information compares to 214 active hunters in 1988 harvesting 193 antelope for a success rate of 90.2%. Opening day of firearms season accounts for nearly 80% of the total harvest.

GENERAL

Presently, no research or transplanting projects are being done.

MONTANA ANTELOPE STATUS REPORT - 1990

C. Robert Watts, Montana Department of Fish, Wildlife and Parks, Lewistown

Trends in population size and composition are determined by fixed-wing aerial surveys. Entire hunting districts, trend areas or selected counting units are flown at least once every three years, most often during July. Yearling males, adult males, females, fawns, and location are recorded for each antelope group. Total numbers in recent years have increased and remain above the long-term averages.

All antelope hunting in Montana is by permit. Limited either-sex permits issued through a random drawing, and valid within a large geographic area (administrative Regions 6 and 7) are available for most of Montana's antelope. This system has evolved from either-sex permits issued by Hunting District, the system still is used in the remainder of the state. Additionally, an unlimited number of doe or fawn permits are available, one per hunter, for nearly all of eastern Montana. Unlimited either-sex and doe/fawn permits, one of each per hunter, are available to archers.

Nonresidents may be issued up to 10% of the limited either-sex permits and are not restricted when buying the doe or fawn permits. Landowners receive 15% of the limited permits. In 1989, the cost of resident and nonresident antelope tags was $8 and $100, respectively, with resident and nonresident doe/fawn tags costing $6 and $25.

Archery seasons begin in early September and run through the second weekend in October. Rifle seasons start at the close of archery season and generally run for four weeks.

Recent statewide harvests and participation are as follows:

Year	Licenses or permits issued	Number of hunters	Harvest
1986	42,631	35,528	36,470
1987	46,525	39,109	39,283
1988	46,295	38,379	39,290

Montana's quality sagebrush-grassland habitat continues to disappear. Sodbusting continues and has been accelerated in recent years because of the CRP program.

The Montana Wildlife Division is not currently engaged in antelope research. Pyrah completed a ten-year study of population ecology in 1987. My recent study of survey efficiency has been completed and will be reviewed at this workshop.

NEW MEXICO PRONGHORN STATUS REPORT - 1990

Mike Bell, New Mexico Department of Game and Fish, Roswell

POPULATION

New Mexico's pronghorn population has been estimated at 30,000 animals in past years. The population in the southern half of the state has declined due to poor fawn recruitment as the result of several years of dry weather and poor range conditions. The northern portion of the state has had favorable conditions, so the herds are stable to increasing. In 1988, 56 population and fawn surveys were conducted in 36 of the 72 antelope units with a minimum estimate of 12,000 pronghorn.

Aerial population surveys have been conducted during March and April in a three year rotation cycle for each unit. Surveys were flown at a 100% level with 0.5-mile wide strips or a 33% level with 1.5-mile wide strips. Fawn survival surveys were flown in July in units as needed. There was no set flight pattern, but a minimum of 100 females were counted. Personnel and 40-hour work week constraints have reduced time available for surveys.

Several ideas to improve efficiency were tried after a review of survey techniques listed in the proceedings from pronghorn workshops. A combined population and fawn count was tried in August, but the large size of fawns made accurate classification difficult. Agreements with landowners for hunting pronghorn are concluded before July, so August information was too late to be included in the current year's agreements.

A representative quadrant in some units was established in an effort to provide a smaller area that could be flown annually to determine population trend. This was complicated by defining a representative area considering pronghorn movement in response to forage and water availability in large units. A further complication came from landowners that disagreed with the ability to count all pronghorns from the air and, specifically, on their ranches. The aerial counts were either higher or lower than the counts done on the ground. Currently, we are in the discussion stage about surveying and harvesting by ranch or using trend and setting harvest by unit.

HUNTING

There have been 14 archery, muzzleloader and rifle hunts in which the Department concluded hunt agreements with over 800 landowners. Agreements are signed with each ranch to allow hunting for a specific number of public licenses drawn by lottery and a specific number of hunters that the landowners authorize to purchase a license. Hunters are restricted to specific ranches.

This has become a very time consuming process, so a full-time position was created just to handle the paperwork aspect of preparing hunt agreements. In 1990, the archery and handicap hunts have an unlimited number of licenses, and the hunters must make arrangements with landowners to hunt. This was done at the request of the statewide bowhunters' organization. It will also provide an evaluation to expanding this procedure to other hunts.

In 1987, there were 6,554 applicants for 2,070 public licenses. The hunt projections indicate that 6,529 public and private licenses were issued, 6,302 hunters harvested 5,062 pronghorn for a success rate of 80%. Archery success is about 10%, muzzleloader about 50% and rifle 80-90%.

Hunter harvest questionnaires have been attached to the license in an effort to improve questionnaire response. Mail card questionnaires mailed after the hunt had less than a 30% response. The response rate from the license questionnaire has not been calculated, but it appears to have a greater response rate and provide more complete information.

TRANSPLANTS

The Bureau of Land Management (BLM) and the Game Department have a Cooperative Agreement to transplant pronghorn into historical BLM range where populations have been reduced or extirpated. Criteria developed through the Roswell BLM pronghorn study are used to evaluate habitat and modify management to enhance transplant success.

A transplant in March of 1989 moved 79 pronghorn from private land in the northeast part of the state to BLM land in the northwest part of the state.

ITEM OF INTEREST

The incidence of the parasitic stomach worm, Haemonchus, in the Roswell area was noted in the status report for the 13th Pronghorn Workshop. Several years of above normal precipitation and excellent forage conditions increased pronghorn numbers and the incidence of worms in cattle, sheep, and pronghorns. Livestock operators treated livestock, but there was no feasible way to treat free-ranging pronghorn. Efforts to allow additional sport harvest of pronghorn by increasing doe licenses was met with resistance by local ranchers.

Mother Nature is currently acting as expected. Two years of drought have reduced the range conditions to the point that the herd has been reduced approximately 50% through adult mortality and poor fawn recruitment.

OREGON PRONGHORN STATUS REPORT - 1990

Walt Van Dyke, Oregon Department of Fish and Wildlife, Portland

Inventory methods have not changed in recent years. Census is conducted in late January through early March from fixed-wing aircraft when pronghorns are congregated on traditional winter ranges. The entire winter range is consistently flown annually; we do not use the quadrat or line transect sampling methodology.

During spring 1990 inventory, 16,679 pronghorn were counted, which is second only to the spring 1988 count of 16,891. The 1990 spring population is estimated at 25,000 pronghorn, up from the 1988 estimate of 23,000 animals. However, this figure probably does not reflect a representative count for several reasons:

1. The winter of 1989-90 was quite mild, and some animals were counted on traditional summer ranges;

2. Pronghorn have been slowly colonizing previously unoccupied habitat, which was created as a result of wildfires experienced over the last five years;

3. In Game Management Units where more normal winter conditions were experienced, counts indicated that the population trend was upward; and

4. Overall fawn survival was comparable to prior years during which we documented steady population growth.

Herd composition counts are conducted in early August from fixed-wing aircraft, which is just prior to the general rifle season. In 1989, a total of 9,277 pronghorn were classified with ratios of 39 fawns and 31 bucks per 100 does. Some district biologists are experimenting with herd composition counts by conducting them before and after the buck season. In several units where this has been done, ratios collected postseason are equal to or higher than those collected prior to the season. This is probably due to the inability to locate groups of bachelor bucks prior to the rut while still finding them with the doe-fawn groups post-rut.

Oregon basically provides four types of hunting opportunities. Center fire rifle, archery, and muzzleloader hunts are designed to provide a high quality recreational opportunity while we employ damage/population control hunts in areas where pronghorn conflict with agricultural croplands. The resident hunting license costs $9, while the tag costs $25. Nonresident fees are $100 for the license and $125 for a tag. Most applicants have less than a 20% chance of drawing a rifle

buck permit; those successful in drawing a permit are put on a five-year waiting period before they can apply again.

In 1989, 2,045 center fire rifle tags were authorized, and 1,546 bucks were harvested for a 78% success, which is comparable to prior years. In order to maintain the quality of the hunting experience and increase opportunity, split seasons have been authorized in units where there are surplus bucks, but hunter crowding could be a problem. This was first tried in six units in 1989. In these units, tag numbers were doubled, and hunter success was slightly higher during the second hunt period, which is most probably explained by the fact that the second hunt occurred nearer the rut.

A total of 660 archery permits were authorized in 1989, which resulted in 364 hunters taking 29 bucks for an 8% success rate. Archery success is currently on an upward trend. Field biologists believe this is due to hunters taking more time to scout and increasing use of blinds at water holes.

Success of muzzleloaders is variable. Fifty muzzleloaders took one buck in 1989 for a success rate of 2%, which is down from the 13% success recorded in 1988.

One hundred and five permits were authorized in 1989 for damage control hunts on which 59 hunters were successful for a 63% success rate. Success with this type of hunt varies greatly among years depending on the location of the antelope as dictated by environmental conditions and attitude of landowners on whose property the pronghorn are residing at the time of the hunt.

Range conditions are improving slightly due to a series of wildfires experienced the last five years in which approximately 500,000 acres burned, mostly on Bureau of Land Management lands. The main benefit of these wildfires to pronghorn is opening up of the canopy of tall, dense stands of sagebrush. Undoubtedly, it would be more beneficial to use controlled burning to improve habitat quality for pronghorn because burns could be designed to create more habitat diversity.

Rehabilitation efforts are variable; for the most part we encourage revegetation by natural means. Where native seed sources are not available, the department participated in rehabilitation of some of these burns by providing seed mixes of palatable forage species. In addition, as part of rehabilitation efforts, we encourage resting the areas from use by cattle until the seedings become established.

There is a serious concern with proposed cyanide leach gold mining developments. The impact these operations may have on pronghorn have not been determined, but there is concern with the

effects of roading and associated improved human access as well as the potential for surface and ground water contamination.

Currently, we do not have any field research projects in progress. However, we are starting to develop population models that can be used to predict harvest potentials.

SOUTH DAKOTA ANTELOPE STATUS REPORT - 1990

John Wrede, South Dakota Department of Game, Fish and Parks, Rapid City

South Dakota's antelope population has continued to grow in the past two years in response to vacated habitat caused by severe winterkill during the winter of 1985-86. Mild winters, near-normal reproduction in spite of drought and very conservative hunting season designs have also likely contributed to the population recovery. Pre-hunt populations in 1988 stood at 20,836 animals. In 1989, the population level rose to 34,943 animals. At this writing, South Dakota's aerial census is underway, and preliminary projections seem to suggest that the 1990 population will stabilize at close to 1989 levels. Localized small increases are expected in some management units, but the comprehensive statewide population is not expected to exceed 36,000 animals. This figure still exceeds the 48-year trend average of 24,641 animals. Table 1 illustrates brief population and harvest statistics from the year 1941 through 1989.

South Dakota's primary antelope range rests along the western edge of the state, bordering with the states of Montana and Wyoming. The counties of Harding, Butte, Fall River, and portions of Meade and Perkins have the most suitable habitat; and, therefore, maintain the highest population levels. Antelope can be found in virtually all western South Dakota counties except Gregory County in the southcentral part of the state. In recent years, small populations of animals have begun to establish themselves in several counties in the northeastern part of the state along what once was a Tall Grass Prairie Chateau surrounding South Dakota's Glacial Lakes Region. These small populations have appeared to do remarkably well considering that there is no traditional antelope range, as we understand it, in the region. The counties of Spink, Brown, Clark, Marshall, Day and Codington are predominantly agricultural in nature, and these animals seem to have found a niche in the few remaining pasture lands scattered throughout those counties. In 1989, projected population for the northeast was established at approximately 100 animals. Counties along the eastern border of the Missouri River have also witnessed, a now-stabilized population of antelope develop over the past few years. Although the area is typical tame and native rangeland, void of sage and checker-boarded with small grain fields and center pivot irrigation systems, the antelope have established themselves in small pockets in five counties. (See Table 2 for 1989 Management Unit descriptions which illustrate general antelope distribution in South Dakota.)

Antelope in South Dakota are principally managed by individual conservation officers in their assigned districts that generally follow county line boundaries. Late spring aerial

census of adult populations using a 33 1/3 sampling technique is conducted by the conservation officers and data gathered is used by the C.O. as well as statewide Game Management Staff. Management units with very low density populations (less than 0.10 antelope per square mile) are generally surveyed from the air every other year, or ground count observations and landowner surveys are conducted to maintain population estimates and develop harvest recommendations.

Random doe/fawn surveys from the ground are being continued to determine reproduction and fawn survival up to the hunting seasons. In 1989, two separate surveys were conducted to determine degree of error in observability between the midsummer survey period and the late summer/early fall period. The late summer/early fall survey period showed a greater doe/fawn ratio than did the earlier period, suggesting that fawn observations and their resulting doe/fawn ratios were due to increased observability. Comparing the doe/fawn ratios developed by using random ground counts with historical ratios developed by aerial censusing, indicates that comparable ratios are obtainable. We continue to wrestle with statistically invalid correlations between observed natality/fawn survival and recruitment. In 1989, the statewide mean reproductive rate was calculated to be 77 fawns per 100 does with a range of 100:133 to 100:46.

The 1989 antelope rifle season was held from October 7-15. A total of 4,433 resident licenses were issued. The projected kill was 3,702 antelope for a 84% success rate. Of the total antelope killed, 77% were bucks and 23% were does.

Archery antelope season was held from August 19 through October 31, 1989. There were 241 resident and 18 nonresident licenses issued. Projected kill was 34 antelope for a success rate of 13%.

A special archery antelope season was held in the northeastern quadrant of the state from August 19 through October 31, 1989, for resident archers only. Sixty permits were issued. Projected kill was 26 antelope for a projected success rate of 43%.

Firearm antelope hunters in South Dakota may use either rifles or handguns that develop a minimum of 1,000 foot pounds of energy at the muzzle as rated by factory specification. Hunters who use primitive firearms are confined to use black powder type weapons of at least 42 caliber.

In 1988, South Dakota implemented a new hunter harvest subsampling survey to replace the old hunter report card system. A random selection of a predetermined percentage of hunters from each hunting unit were contacted by mail and asked to respond to several questions pertaining to their antelope hunt. A follow-up

mailing was done to improve the reporting percentage and the confidence limits. Results of the new technique appear to be excellent. Accuracy also seems to be as good or perhaps better than the hunter report card system.

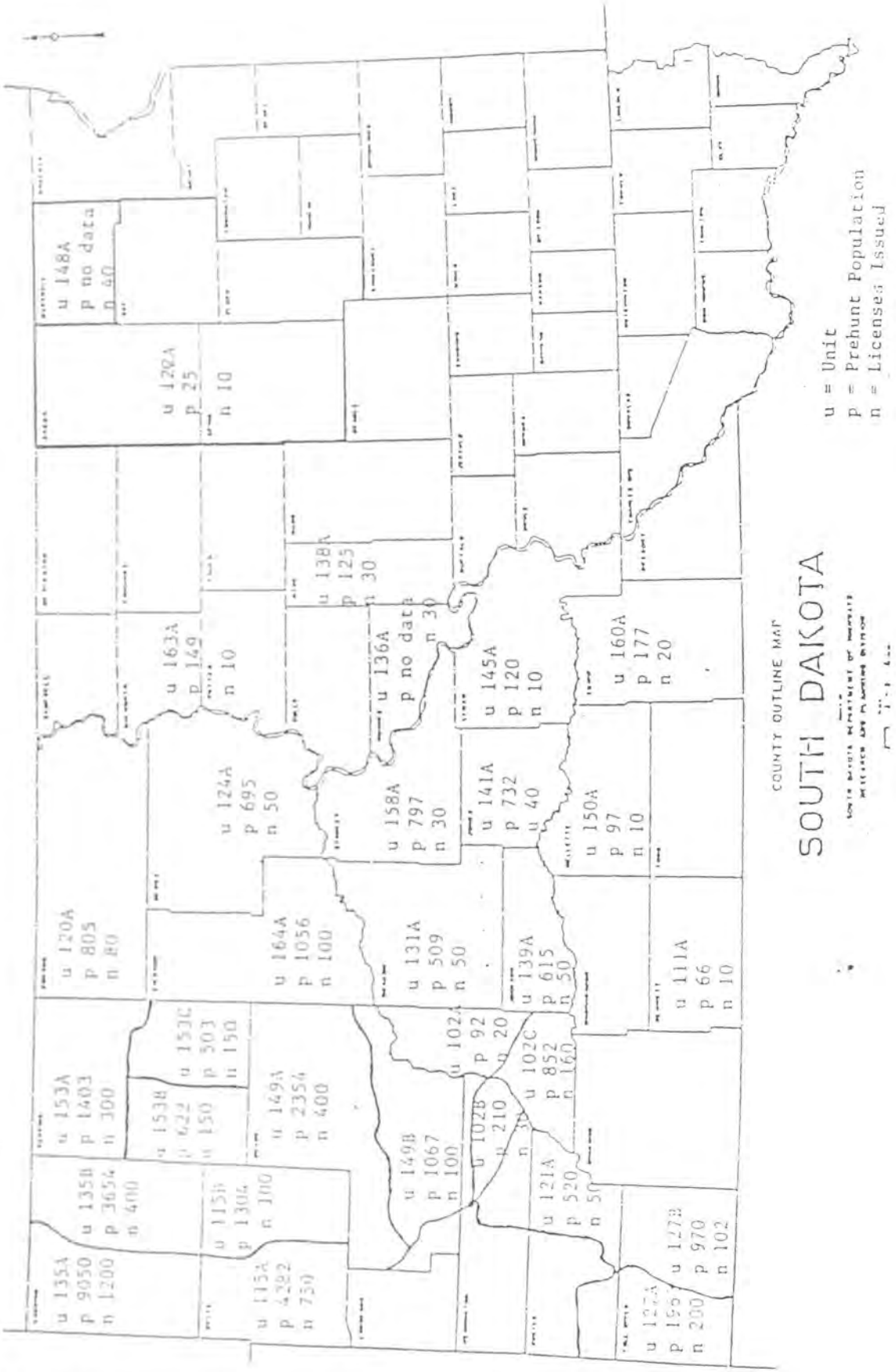
Migrational movements of antelope are of interest to antelope management in South Dakota. During the winter of 1985-86, migration occurred to the south and east leaving noticeable gaps in the normal antelope distribution in the primary range. As late as the spring of 1990, antelope movements appear to be the cause of population fluctuations in several management units. It appears that there may be significant movement back and forth between South Dakota and the states of Wyoming and Montana, which could frustrate strategies in all three states.

South Dakota's antelope movement objectives have remained relatively constant since 1986. Herd rebuilding and maintenance continues to be the most important effort. Hunter selectivity, appropriate distribution of antelope and small grain depredation abatement are the state's greatest concerns. Efforts are also being made to find suitable harvest rates that will assist in retarding historical bust and boom populations and license regulations. A ten-year trend analysis of all antelope management units has been completed and will be distributed to individual conservation officers for their review and use when recommending harvest quotas.

Year	Population in area censused	Number of licenses sold	Number of antelope killed
1941	10,000	500	480
1942	questionable		
1943	7,973	1,000	976
1944	5,370	500	480
1945	6,721	closed	
1946	9,442	700	609
1947	14,800	2,000	1,875
1948	13,000	2,549	2,371
1949	7,425	closed	
1950	10,920	850	759
1951	14,356	3,350	3,151
1952	16,608	8,350	7,880
1953	15,090	5,244	4,750
1954	16,756	5,700	5,196
1955	16,664	4,850	4,281
1956	19,374	6,266	5,616
1957	16,885	4,415	3,885
1958	16,235	3,300	2,900
1959	20,272	5,569	4,950
1960	23,330	6,708	6,037
1961	27,480	8,596	7,990
1962	26,382	6,991	6,152
1963	27,658	8,090	7,280
1964	24,566	7,470	6,050
1965	27,286	8,750	6,776
1966	20,954	4,965	4,244
1967	23,400	6,547	4,847
1968	22,142	3,229	2,419
1969	23,595	4,382	2,880
1970	25,100	4,850	3,807
1971	34,690	7,004	5,452
1972	34,894	7,225	6,370
1973	33,128	7,770	6,831
1974	41,358	10,114	8,542
1975	43,083	12,139	10,331
1976	33,505	8,340	6,722
1977	40,390	9,335	7,592
1978	28,425	5,849	4,714
1979	18,333	3,128	2,473
1980	25,402	5,236	4,408
1981	37,277	7,804	6,530
1982	53,934	13,899	11,145
1983	67,281	17,439[a]	14,697
1984	61,644	15,388 (22,456 tags)	16,999
1985	48,741	12,656 (16,320 tags)	12,601
1986	14,570	1,484	953
1987	15,753	1,690	1,271
1988	20,836	2,274	1,779
1989	34,943	4,433	3,702

[a]Includes 4,000 bonus doe/fawn tags.

Appendix Table 1. Trend in antelope population hunting licenses sold and hunter harvest, 1941-1989.



Appendix Table 2. 1989 Antelope Management Units.

TEXAS ANTELOPE STATUS REPORT - 1990

Danny A. Swepston, Texas Parks and Wildlife Department, Alpine

Historically, pronghorn antelope were distributed over most of Texas west of the 97th meridian. However, their current range is confined to scattered locations in the High Plains, Edwards Plateau, and Trans-Pecos Ecological Regions.

Data on antelope populations is reported by three administrative districts of the Wildlife Division where pronghorn occur; Trans-Pecos, Panhandle, and Possum Kingdom. Population estimates and herd composition are obtained by aerial strip counts during mid-June through July in areas containing major concentrations. Similar data is gathered by ground counts in peripheral antelope range.

For the period of 1977-89 the Texas pronghorn population has varied from 12,000 to 26,800 averaging about 18,500 with approximately 70% occurring in the Trans-Pecos, 20% in the Panhandle, and 10% in the Possum Kingdom District of westcentral Texas. Pronghorn numbers statewide declined about 46% from 1987 to 1989 because of an extended drought. Recent rains in the Panhandle and Possum Kingdom Districts should reverse this trend in these areas. However, the statewide population may still show a decline in 1990 because of continued dry conditions in the Trans-Pecos.

The nine-day hunting season opens the Saturday nearest October 1. The bag limit is one pronghorn per hunter per season. All pronghorns legally taken in Texas since 1941 have been by permits issued by the Parks and Wildlife Department. Permits are issued at a rate to maintain the pronghorn population at the carrying capacity of the range and to maintain a post hunting season adult sex ratio of 1 buck per 4 does. The permits may not be sold; however, the hunter must negotiate with the landowner to obtain access to hunt. The Elephant Mountain Wildlife Management Area in the Trans-Pecos and the Rita Blanca national Grassland in the northern Panhandle are the only public lands open to antelope hunting in Texas. Hunters for both areas are chosen by an impartial drawing conducted by the Parks and Wildlife Department.

The number of hunting permits issued varies from about 900 to 2,500 annually and averages about 1,500. Harvest of pronghorn during the period of 1977-89 ranged from 538 in 1983 to 1,017 in 1987. Hunter success is high, averaging 92%. The harvest of pronghorns is very conservative, as reflected by the permit utilization rate, which averages 48%.

Relocation efforts in Texas during the last three years have been limited to the movement of 38 pronghorns in 1987 because of the limited brood stock.

Recent research projects have included a study to determine the subspeciation of pronghorn in the Permain Basin and Trans-Pecos populations and an attitude survey of Texas landowners whose property contain antelope.

The subspeciation study was completed in 1988. Based on the results, no pronghorn populations in the two areas sampled can be assigned to the American (Antilocapra americana americana) or Mexican (A. a. mexicana) subspecies at this time. However, the antelope population in the Marathon Basin in the Trans-Pecos region was found to have a distinct genetic makeup. It was recommended that antelope from outside this area not be released into the Marathon area in order to maintain this genetic pool.

The landowner survey indicated pronghorns on the ranches sampled were typically indigenous (80.5%), fenced wholly or in part with net wire (52.5%), and were hunted during at least one of the three years prior to the 1989 survey (89.1%). Statewide, 56.9% of the landowners elected not to issue all the permits they received. A desire to increase the quality of their bucks, increase numbers of antelope on their property, and poor hunter demand were the reasons given for not using all their permits. Statewide, hunter access to pronghorns is about equally divided between fee and no fee arrangements with landowners. A majority of the respondents consider pronghorns on their property to be an asset.

A new study concerning the relationship of fawn mortality and fawning sites in Hudspeth County in the northern Trans-Pecos region was initiated by Texas Tech University in March, 1990.

WYOMING ANTELOPE STATUS REPORT - 1990

Phil Riddle, Wyoming Game and Fish Department, Green River

The current population objective for antelope in Wyoming is 381,660 animals postseason. We estimated in 1988 that we had approximately 344,794 postseason. Our harvest in 1989 was about 54,355.

Two problems continue to plague our management efforts. The northeastern third of the state is mostly private land and subsequent access fees and lack of access prevent obtaining desired harvests. Fencing continues to cause us grave concern for the future of antelope on public lands. BLM continues to utilize fencing to solve administrative problems. We are currently at odds with the Wyoming Highway Department over a fence that perpendicularly intersects a migration route for over 10,000 animals in the largest antelope herd in the state. It has the longest migration route of any herd in the state. Tagging information shows movements of over 200 miles.

In the southcentral and southwestern part of the state we are starting to encounter demand problems. We do not have enough hunters to accomplish a harvest in some areas. In 1989, we allowed hunters to purchase as many doe/fawn licenses as they wanted but are having to limit the total to five additional because of public outcry that asserts many people are killing more than they can use and are wasting them.

We have changed management philosophy over the years from one of issuing just "any" antelope permits to "any" and doe/fawn licenses. That has satisfied the need to produce more trophy bucks and to stabilize population numbers. It has allowed a tremendous increase in recreational opportunity as we are issuing more permits in some areas than we were able to stand when hunting with "any" antelope licenses.

Finally, our state is in the fourth year of a drought, and the southwestern half of the state is classified as critical on drought indexes. That factor and accelerated poor range conditions are causing some populations to drop to half of normal reproduction rates.

TECHNICAL SESSION

DETERMINING A MINIMUM GENETICALLY VIABLE POPULATION SIZE FOR YELLOWSTONE PRONGHORNS

M. Douglas Scott, Research Division, Yellowstone National Park

Historic data from ranger sightings, superintendent's reports, and other monographs indicate that Yellowstone pronghorn antelope have been almost completely geographically isolated from all other pronghorns for at least 100 years, and possibly much longer. Additionally, whereas most pronghorn herds in surrounding states were replenished in the 1930s - 1950s with stocked animals from other areas, the Yellowstone herd has never been known to be contaminated by outside gene pools as the result of human intervention. Clearly, Yellowstone antelope constitute a unique genetic resource that is worth preserving. Apparent isolation of the herd, its comparatively small size, and past severe drops in numbers are all cause of concern about its long-term viability. Viable animal populations must be able to: a) maintain genetic diversity (heterozygosity); b) withstand stochastic events which may suddenly deplete numbers; c) withstand systematic pressures which slowly change environmental conditions; and d) control population losses through emigration of individuals. Large-scale emigration from the Yellowstone herd has never been documented. Stochastic events and systematic pressures may have large effects on the herd regardless of its size, but the bottom line is that any population must at least maintain enough genetic diversity so that it does not founder due to deleterious effects of inbreeding. If this minimum number is not maintained, the population may more-or-less "self-destruct," even without severe stochastic or deterministic events. Recently-published methods were used to determine the effective population size (Ne) of the Yellowstone herd(s) at various times and places. (Ne is defined as the size of an idealized population that would have the same amount of inbreeding or random gene frequency drift as the population under consideration.) Methods used corrected Ne for: a) overlapping generations; b) unequal lifetime progeny production; c) non-normality of the dispersal distribution; and d) low rate of immigration. A Ne value of 50 is often used as the lowest effective population with an acceptable rate of inbreeding, at least in the short term. This value limits the inbreeding coefficient to 1% per generation and assumes no immigration from outside herds. If ongoing analyses of mitochondrial DNA and gene allozymes suggest that, in fact, some immigrants have crossed with Yellowstone pronghorns over the years, the minimum acceptable Ne would be reduced. For example, if one immigrant bred with one Yellowstone herd member every ten years, the Ne for a 1% inbreeding rate would be reduced to only 31 animals. Using pronghorn age and sex ratio data, census data and estimated survivorship curves, a minimum April breeding-age population census of 184 produces a Ne of 50. If, as suspected, there is one relatively static herd and a second, migratory herd in Yellowstone, each herd would need at

least 184 breeding-age animals (Nba =184). When including nonbreeding yearlings and fawns, July counts of the two herds would have to be 223 each (N = 223). After several good years of pronghorn reproduction, the 1988 April count for the static herd was Nba = 350, producing a Ne of 96; with a subsequent July count of N = 423. The respective values for the migratory herd were Nba = 150, Ne = 41, and N = 181. Thus, even under favorable conditions, the migratory herds had not achieved acceptable genetic security. If, however, the two herds are not distinct, the values become Nba = 500, Ne = 137, and N = 604. Large fires and drought in summer 1988 on pronghorn range, followed by a very untimely fall "depredation" antelope hunt just north of the park boundary, were then succeeded by a normally-severe winter. Evidently, these conditions combined to greatly reduce Yellowstone's pronghorn herd. As of 1 April 1989, the static herd had a Nba of 260 and a Ne of 78, while the migratory segment was reduced to a Nba of 112 and a Ne of 31. It is apparent that one bad year can decimate the Yellowstone pronghorn population to the point of serious concern for genetic viability. The low point for Yellowstone's pronghorns appeared to be between 1969 and 1982, when the total herd appeared to fluctuate around a Nba of 150, with a Ne of 41. The static herd alone probably had a Ne of 29, while migrants would have had a Ne of only 12. It is certain that the herd went through a genetic bottleneck in those years, and the reduction in heterozygosity may help to explain why Yellowstone pronghorns now show very few differences in external morphology among the sexes as compared to herds outside the park. Maintenance of the Yellowstone pronghorn herd will require more research, more careful monitoring, and eventual active management of the animals. More precise calculations of minimum genetically viable pronghorn population sizes can only be made if more information is gathered on survival rates of all age classes, dispersal distances, variance in lifetime progeny production, fidelity to breeding/birthing areas, and breeding success among nonterritorial males. The only practical way to gather most of this information is through the use of radiotelemetry technology. Without such information, intelligent management of Yellowstone's pronghorns would be greatly restricted--possibly eventually leading to loss of the resource.

PRELIMINARY RESULTS OF GENETIC VARIATION IN PRONGHORN

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Abstract: One major objective of a translocation program dealing with a fragmented population should be the preservation and/or enhancement of endemic genetic variation. Genetic variation in 340 North American pronghorn (*Antilocapra americana*) from 21 geographically isolated populations was assessed by protein electrophoresis and mitochondrial DNA restriction enzyme analysis. The United States and one Canadian province from which these samples are taken include: Alberta, California, Colorado, Idaho, Kansas, Montana, New Mexico, Nebraska, North Dakota, Oregon, Texas and Wyoming. Although this study is not complete, allele frequency differences do occur between pronghorn populations. Mitochondrial DNA variation is detectable among populations with the use of protein electrophoresis. Managers of pronghorn populations should recognize that these populations are genetically complex and possibly composed of gene pools from five subspecies. Based on present information, no pronghorn population is assignable to these historic taxa.

ESTIMATING PRONGHORN NUMBERS WITH AERIAL LINE TRANSECTS

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Abstract: Aerial transect sampling was evaluated in 1987 and 1988 as a technique to estimate pronghorn (*Antilocapra americana*) numbers. We found that assumptions required by the line transect technique could be met if sampling protocols were followed. Line transect estimates were 90-127% of population model estimates, and trend counts 52-78% of line transect estimates in herd units surveyed. Adequate line transect samples were obtained in 19-51% of flight time required for trend counts. Confidence intervals around population estimates could generally be narrowed by designing the survey with a knowledge of pronghorn dispersion and increasing sample size.

A manual, "Guidelines for estimating pronghorn numbers using line transects," and a training video are available from the Wyoming Game and Fish Department, 5400 Bishop Blvd., Cheyenne, WY 82006.

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EFFECTS OF DOMINANCE ON REPRODUCTION IN FEMALE PRONGHORN

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Abstract: Aggressive behavior and reproduction of 26 marked female pronghorn (*Antilocapra americana*) were observed 24 May - 13 October 1989 to determine the reproductive correlates and fitness benefits of dominance. The study animals occupied 3 adjacent home ranges in Middle Park, Colorado. Dominant females tended to bear more fawns than did subordinates; mean parturition date of dominant females was 7 days earlier than that of subordinate females. Fawns of dominant females were not heavier than fawns of subordinates and there was no sex bias among fawns born to dominants or subordinates. Dominant females did not wean more fawns than did subordinates, nor was there a sex bias among fawns weaned. Fawn survival varied from 26 to 91% among home ranges, suggesting that factors other than dominance were important. Future study will reveal the effect of annual variation on detecting the fitness benefits of dominance. However, these results emphasize the importance of spatial variation in subdivided population within a season.

Intrasexual aggression is widely recognized as a major factor determining male reproductive success in mammals (Partridge and Halliday 1984). However, because female behavior affects offspring production and survival during breeding, gestation, and maternal care, a female's relative competitive status may contribute significantly to her reproductive success (Hrdy and Williams 1983). A dominant female may increase her reproductive success by: 1) breeding with quality males, 2) aggressive inhibition or delay of reproduction in subordinates, 3) improved access to resources, and 4) direct aggression toward offspring of competitors.

In the stable, cohesive, social groups of primates, long-term benefits can be realized from aggressive inhibition of reproduction and direct aggression toward unrelated offspring (Wasser 1983). Due to the less cohesive social organization generally found in ungulates, and particularly in pronghorn, access to resources which may be invested in offspring is likely a more important effect of dominance than aggressive inhibition of reproduction. Dominant female red deer (*Cervus elaphus*) had higher lifetime reproductive success than subordinates, but the behavioral mechanisms involved were not studied (Clutton-Brock et al. 1986). Female bison (*Bison bison*) that received aggression during foraging suffered decreased foraging efficiency, but the relationship to individual reproductive success was not known (Rutberg 1986).

This paper reports the preliminary findings of a 3-yr study on the effects of aggression among female pronghorn on annual reproductive success. The objectives were to determine the

reproductive correlates and fitness benefits, in terms of number of fawns weaned annually, of dominance.

Partial funding was provided by Sigma Xi Grant-in-Aid; Theodore Roosevelt Memorial Fund of The American Museum of Natural History; The Graduate School and Department of Systematics and Ecology at The University of Kansas; and a General Research Fund Grant to K. B. Armitage from the University of Kansas. I thank R. Firth, J. Liewer, J. Luft, E. Tousimis, D. van Schmus, and K. Zuby for help in the field. I am grateful to the Colorado Division of Wildlife, and T. Pojar in particular, for encouragement and for providing telemetry equipment. K. B. Armitage contributed helpful discussion; J. Koprowski and S. Min reviewed the manuscript.

METHODS

Fieldwork was conducted 24 May to 13 October 1989 in Middle Park near Kremmling, Colorado. The elevation of the shrub-steppe habitat is 2,230-2,795 m with an average annual precipitation of 35.6 cm. The dominant vegetation is big sagebrush (Artemisia tridentata). The naturally recolonized pronghorn population consisted of about 160 animals before the 1989 fawning season.

Twenty-six females, recognizable by radio collars, plastic neck bands, or natural markings, and occupying 3 different home ranges were observed during fawning season. Parturition date and the number and sex of fawns born were recorded for individual females. Twenty-five fawns of 16 females were captured within 3 days of birth, weighed, and marked with a colored ear tag in each ear for individual recognition. Although ages of the fawns upon first capture varied from 1-3 days, weight was not correlated with days since birth ($r = 0.0$). Therefore, mean weights were calculated without correcting for age of fawns. Fawn survival was monitored to the beginning of the rut, 15 September.

A dominance hierarchy was constructed for females in each of the 3 home ranges based on interactions recorded during 20- to 30-min focal animal samples and ad lib observations. Females were ranked to minimize deviations from linearity (Schein and Fohrman 1955). The hierarchies consisted of 12 females in the Red Mountain (RM) home range, 9 in the Sulphur Gulch (SG) home range, and 5 in the Corral Creek (CC) home range. Females in the upper half of each hierarchy were considered dominant and females in the lower half were considered subordinate. In hierarchies with an odd number of females, the median-ranked female was considered dominant.

Number of fawns born and number of fawns weaned by dominants versus subordinates were compared statistically using the Wilcoxon rank sum test (Ott 1984:146). Means were compared with a 2-sample t-test assuming equal variances (Sokal and Rohlf 1981:226). Fawn sex ratios were tested for deviation from 1:1 with G-tests (Sokal and Rohlf 1981:698).

RESULTS

Dominant females tended to give birth to more fawns than did subordinates (Table 1). There was no sex bias observed among fawns born to dominant females or to subordinate females

Table 1. Reproductive and fitness correlates of dominance ($\underline{x} \pm$ SD; $\underline{n}$ in parentheses) in female pronghorn, Middle Park, Colorado, 1989.

	Fawns Born	Fawns Weaned	Parturition Date (days past 31 May)	Fawn Weight (kg)[1]
DOM	1.8 ± 0.42	0.7 ± 0.85	6.9 ± 4.05	4.0 ± 0.40
	(10)	(13)	(8)	(13)
SUB	1.5 ± 0.52	0.8 ± 0.84	13.9 ± 3.85	4.0 ± 0.39
	(12)	(12)	(7)	(10)
statistic[2]				
	$\underline{z}$ = 1.423	$\underline{z}$ = -0.461	$\underline{t}$ = -3.42	$\underline{t}$ = 0.00
$\underline{P}$	0.077	0.32	<0.005	1.0

[1]$\underline{n}$ = number of fawns. Number of females = y dominants, 7 subordinates.
[2]Comparisons involved two-sample $\underline{t}$-tests assuming equal variances or Wilcoxon rank sum test ($\underline{z}$).

(DOM: 10M:8F, $\underline{G}$ = 0.223, $\underline{P}$ = 0.64; SUB: 9M:5F, $\underline{G}$ = 1.159, $\underline{P}$ = 0.28). The sex ratio of fawns born did not differ between dominant and subordinate females ($\underline{X}^2$ = 0.258, $\underline{P}$ = 0.97).

Dominant females bore fawns significantly earlier than subordinate females (Table 1). Dominant females gave birth 7 days earlier than subordinate females in a fawning season only 18 days long. Fawns of dominant females were not heavier than fawns of subordinate females (Table 1).

Dominant females did not wean more fawns than did subordinates (Table 1). Sex ratio of fawns weaned did not differ from 1:1 for dominant or subordinate females (DOM: 6M:3F, $\underline{G}$ = 1.019, $\underline{P}$ = 0.31; SUB: 6M:4F, $\underline{G}$ = 0.403,$\underline{P}$ = 0.52). The sex ratio of fawns weaned by dominants was similar to that of fawns weaned by subordinates ($\underline{X}^2$ = 0.929, $\underline{P}$ = 0.99). Mean birthdate of fawns surviving to 15 September did not differ from nonsurviving fawns (SURV: 9.1 ± 4.42 days past 31 May, $\underline{n}$ = 12; NONSURV: 9.7 ± 5.50 days, $\underline{n}$ = 13; $\underline{t}$ = 0.299, $\underline{P}$ = 0.76). Fawns surviving to 15 September were not heavier within 3 days of birth than fawns that did not survive (SURV: 4.0 ± 0.28 kg, $\underline{n}$ = 12; NONSURV: 4.1 ± 0.54 kg, $\underline{n}$ = 13; $\underline{t}$ = 0.390, $\underline{P}$ = 0.70).

Data from females occupying 3 adjacent home ranges were combined to increase sample sizes for the above analyses. However, it was apparent by September that fawn mortality differed among home ranges. Fawn mortality was relatively low on the Red Mountain and Corral Creek home ranges: 26% on RM (5 of 19 fawns) 33% on CC (2 of 6 fawns). Fawns in Sulphur Gulch, which lies between the other 2 home ranges, suffered 91% mortality (10 of 11 fawns), significantly higher than that on RM ($\underline{X}^2$ = 11.627, $\underline{P}$ = 0.009). The sample size on CC was too small to test statistically, but mortality was similar to RM. Within the RM home range, the 6 dominant females weaned 8 fawns; the 6 subordinate females weaned 6 fawns ($\underline{G}$ = 0.287, $\underline{P}$ = 0.59).

DISCUSSION

In a highly synchronized fawning season, dominant females gave birth a week earlier than subordinate females, suggesting a biologically important relationship between dominance status and parturition date. Fawns born later may have a reduced probability of surviving a severe winter their first year due to a shorter growing season. First year mortality of red deer calves was higher for fawns born after the median calving peak than for those born before (Clutton-Brock et al. 1982). All marked fawns that survived to weaning in the study, survived the mild 1989-90 winter in Middle Park.

Earlier parturition dates in dominants could result from several possible mechanisms. Dominant females may delay breeding in subordinates by directly interfering in breeding attempts or by aggression-induced delay of estrus in subordinates (Wasser and Barash 1983). Alternatively, dominant females may come into estrus earlier than subordinates due to better access to food resources. Clutton-Brock et al. (1986) suggested that body condition of female red deer may affect conception date. Although the causal relationships are unknown, heterozygosity is correlated with both dominance and conception date in white-tailed deer (Chesser and Smith 1987).

Age of females may also affect reproductive and fitness parameters investigated in this study. Dominance rank was not related to age in female pronghorn on the National Bison Range (Kitchen 1974). However, age may be an important factor in reproductive parameters. Evidence from captive pronghorn suggests that yearlings come into estrus later than mature females (Pojar and Miller 1984). More experienced females may successfully rear more fawns than younger females, as in white-tailed deer (Odocoileus virginianus) (Ozoga and Verme 1986).

Exact ages were known for 6 female pronghorn in Middle Park; minimum ages were known for 17 females. Sample size prohibited statistical analysis of the effects of age on the reproductive and fitness parameters. In future years, the age of more females will be known and the effects of age will be investigated.

Neither the tendency of dominants to give birth to more fawns nor the early parturition dates of dominants translated into higher annual reproductive success in 1989. Differences in reproductive success between dominants and subordinates may only be detected over a longer time period due to annual variation of environmental conditions and fawn mortality factors unrelated to the mother's dominance status. Lifetime reproductive success is probably a better measure of fitness and continued study of this population will elucidate any relationship between dominance and fitness.

Spatial variation of fawn mortality in a single year may also make it difficult to detect fitness benefits of dominance. Fawn mortality varied greatly among the 3 home ranges. Differences in reproductive success among individual females are unlikely to be detected when fawn mortality is very low or very high, as in Sulphur Gulch. By pooling data from 3 home ranges, effects of maternal dominance that might have existed on RM and CC were obscured by low fawn survival in SG.

In field studies, temporal variation is often a problem that can be minimized by including several years (or seasons) in the analysis. However, these results suggest that in subdivided populations spatial variation can be an important factor within seasons. Data from each subdivision should be analyzed separately where practical. Where sample sizes are prohibitive, biologists should at least be aware of the potentially confounding effects of spatial variation when pooling data from a subdivided population.

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BEDSITE SELECTION BY PRONGHORN ANTELOPE FAWNS IN GRAND COUNTY, COLORADO

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Abstract: Pronghorn antelope fawns spend most of their time bedded down apart from their mothers. This behavior is thought to aid fawn survival by concealing the fawn from predators and protecting the fawn from the elements. In this study I attempted to determine whether fawns make a choice of bedsite from the available terrain. Fawns in the Middle Park region of Colorado were observed, and several physical and meteorological measurements were made on their bedsites. In addition, a number of random points in the same area were selected and the same measurements taken on these potential bedsites. Comparing the characteristics of the fawn bedsites to these randomly-selected potential bedsites, I found that fawns were bedding predominantly on hillsides and in sites near the cover of sagebrush.

INTRODUCTION

After birth, pronghorn antelope fawns spend up to 90% of their time bedded down during the first 2-3 weeks (Kitchen 1974). Fawns get up to join their mothers for nursing, then bed down again. However, fawns do not bed in the same place for 2 successive beddings (Autenrieth and Fitcher 1975).

The selection of bedsites by pronghorn fawns is thought to be related to pronghorn recruitment by affecting the ability of predators to locate the fawns. Hamlin, et al. (1984) have shown that mule deer fawn mortality due to coyote predation is influenced by levels of microtine rodent populations. However, Barrett (1984) asserts that while predation may hamper recruitment or population recovery, it does not play a role in population size.

Pronghorn fawns within given populations have been shown to prefer specific site characteristics (Barrett 1984, Tucker and Garner 1983). In addition, Tucker and Garner (1983) assert that proper range management may be of importance to survival of fawns less than 4 weeks old.

This study was done to determine the extent of variation for several physical and meteorological characteristics of bedsites chosen by pronghorn fawns within a pioneering pronghorn population found in Grand County, Colorado. This study also was done to determine whether bedsites chosen by the fawns within that population were significantly different from a random

sample of potential bedsites within the area occupied by the population.

MATERIALS AND METHODS

The study area was located on BLM land in Grand County, Colorado. Study sites were located just North of US Highway 40 between Kremmling and Parshall. Sagebrush is the dominant vegetation, providing nearly all available cover. Post-parturient does were observed until they went to their fawns and nursed them. After nursing, the fawns were observed and their bedsites noted. Each fawn was then approached and captured, and the bedsite marked with flagging tape and the approximate map location recorded. The bedsites were relocated 1 to 10 days later and measurements were made of several site characteristics. For measuring temperature and wind speed, a 1.5-m wooden stake with thermometers at 10 and 100 cm was placed at the center of the bedsite. Wind speed was measured by facing an anemometer into the wind at 10 and 100 cm. Because winds were occasionally gusty, and only one anemometer was available, the anemometer was held at each height for 60 sec and the highest reading at each height recorded. Wind direction was measured by tossing dust or sage leaves into the air and determining their direction of motion with a compass. Distance to the nearest sagebrush was measured from the stake to the nearest twig or leaf of the surrounding sage. The number of bushes partially or wholly within a 1-m radius of the bedsite was recorded. The number of rocks of baseball size or larger within a 1-m radius of the bedsite was recorded. If rocks were present within 1 m, the distance to the nearest one was measured. Depression was measured by placing a meter stick across the bedsite so that the 50-cm mark was adjacent to the stake and measuring at a perpendicular to the meter stick. Each bedsite was designated as occurring within 1 of 5 topographic categories; level ground, base of a hill, hillside, just below the crest of a hill, and crest of a hill.

The study area was divided into 200-m grids on a map. Thirty random sites were chosen by taking numbers from a random number table as grid coordinates. I went to each of the randomly selected sites and further randomized each site by facing away from the site and tossing a small rock with a length of flagging tape attached to it into the site over my shoulder. The rock was then located using the flagging tape and the spot where it landed designated a random bedsite. Measurements were taken in the same manner as for actual bedsites, with the 1.5-m stake placed on the spot where the rock landed.

Means were calculated for depression, distance to nearest bush, number of bushes within a 1-m radius, number of rocks in a 1-m radius, and slope. For temperature and wind speed, the observed differences between readings at 2 heights and the means for such differences would be greatly influenced by day- to-day

differences in weather and by the time of day at which each measurement was taken. Ratios of the measurements at different heights were judged to be more robust, and each 100 cm reading was divided into the 10 cm reading for the same site and means for these values also were calculated. Comparisons between pronghorn fawn bedsites and random sites were made using 2 tailed t-tests for each variable. Where the variances of a given variable for actual and random sites differed by more than a factor of 3, a Mann-Whitney nonparametric test was performed. The presence or absence of rocks and the topographic categories were tested with Chi-square contingency statistics.

RESULTS

For the means of the slope and distance to nearest bush (Table 1), the variances for the actual and random sites were different by more than a factor of 3, while variances for the other variables were quite similar between the random and actual sites.

Table 1. Means and variances for actual and random bedsites.

Variable	(n = 18) Means for fawn sites	(n = 30) Means for random sites	p
Wind speed	0.443 ± 0.229	0.537 ± 0.223	0.18
Temperature	1.173 ± 0.085	1.113 ± 0.066	0.019
Distance to nearest bush	14.385 ± 12.890	27.214 ± 31.127	0.088
Number of bushes, 1 m	6.611 ± 2.947	6.667 ± 4.277	0.96
Number of rocks, 1 m	2.667 ± 3.986	1.933 ± 5.621	0.61
Slope	17.556 ± 16.344	11.067 ± 8.128	0.10

Differences between means for actual and random sites were not statistically significant for wind speed, number of bushes, and number of rocks, (p values 0.18, 0.96, and 0.61, respectively). Difference between the 2 means for temperature was statistically significant ($p = 0.019$), and the differences for distance to nearest bush and slope were borderline cases ($p = 0.088$ and 0.10, respectively). The Chi-square value for presence of rocks (Table 2) was not statistically significant ($X^2 = 2.70$, $p > 0.05$), while the Chi-square value for type of terrain (Table 3) was highly significant ($X^2 = 28.22$, $p < 0.01$).

Table 2. Expected and observed numbers of bedsites with rocks present and with no rocks present.

Presence of rocks	Expected frequency	Observed frequency
Rocks present	3.6	7
Rocks not present	14.4	11

Table 3. Expected and observed numbers of bedsites located on a hillside and not on a hillside.

Terrain	Expected frequency	Observed frequency
On a hillside	6.6	15
Not on a hillside	11.4	3

DISCUSSION

Fawns seem to be bedding close to sagebrush in sites that are on hillsides. Even though the difference between the slopes of actual and random sites was not statistically significant at the $p = 0.05$ level, it probably is biologically significant because it is supported by the result of the Chi-square test for bedsite location. The difference in temperature ratios indicates that the fawns bedded in sites with a higher ratio of temperature at 10 cm to temperature at 100 cm. This may help the fawns avoid risk of death or illness due to exposure. This is in spite of a lack of difference in wind shield (ratio of wind speeds at 10 and 100 cm). However, many wind speeds were not measured at the time of capture, or perhaps more importantly, at the time of bedding. The suitability of a site for providing wind shield would not be likely to be detected after a lag between bedding and measurement because differences in wind direction will result in changes in the effectiveness of the cover provided by the bedsite.

The fawns also seem to be bedding in sites close to sagebrush. The level of significance may be higher than demonstrated here due to the method for selecting random sites. I noticed that the rock used to determine the exact bedsite did not usually come to rest when it struck the ground, but rather bounced for a distance. Since non-moving objects (such as sagebrush) tend to slow or halt the progress of moving objects (such as rocks), I feel the values for distance to nearest bush for the random sites probably are lower than for truly random sites. This might be remedied by replacing the rock with an

object that would cease moving upon contact with the ground, such as a lawn dart.

Conclusions that may be drawn from this study are twofold. First, it seems that the presence of areas within the study site containing preferred bedsite characteristics (sagebrush-covered hillsides) may have been attractive to the pioneering herd. Second, those areas within the study site which can be found to provide ample potential bedsites for this population should perhaps be identified and targeted for conservation or exclusion of potentially destructive human activity.

One question resulting from this study is the possibility that bedsite selection is a fitness trait in pronghorn antelope. For this to be true, it must be shown that bedsite selection is chosen in any given location or environment. For a characteristic to be selected on, three factors must be present. There has to be variability for a trait within a population. There must be differential rates for survival and/or reproductive success resulting from the variation. It must be shown that the trait is heritable and can be passed from one generation to the next. There is evidence that individual fawns consistently choose the same type of bedsite (Barrett 1981), and the results of this study indicate that there is great variability in bedsite characteristics for fawns within a given population of pronghorn. Currently, it is believed that fawn bedsite selection is the result of birth site imprinting (Barrett 1981). If studies were to show that birthing site selection is a heritable trait, then it may be that it is also a survival trait.

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A LARGE STORAGE CAPACITY GUZZLER FOR USE BY BIG GAME[1]

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Yoakum et al. (1980:369) defines a guzzler as "a permanent, self-fulling water catchment similar to a cistern." The guzzler collects rainwater and snowmelt via a collection apron and stores the water for future use by wildlife. The guzzler's main objective is to increase distribution and population of key species in areas where water is a limiting factor. This objective has been achieved for big game on western rangelands (June 1965, Sundstrom 1968, Roberts 1977). From their studies in western Utah, Beale and Smith (1970:580) came to the same conclusion. Guzzlers also benefit songbirds and small mammals.

Distribution of pronghorn antelope (Antilocapra americana) in east-central Nevada is also limited by available water sources. Often time, livestock operators will provide water only in pastures that are currently grazed by their domestic animals. Pronghorn will move into these pastures to take advantage of these water sources and soon leave after depletion of the supply. In response to an observed need for providing yearlong water sources, the Ely District of the Bureau of Land Management (BLM), cooperating with the Nevada Department of Wildlife (NDOW), constructed 2 guzzlers for pronghorn and 1 guzzler for mule deer (Odocoileus hemionus) in 1981. A bid construction contract for a fourth guzzler was awarded in 1983 with construction delayed until 1984. The basic design is borrowed from guzzlers built by the BLM in Utah and Arizona, yet different than what has been previously reported in the literature (Halloran and Deming 1958, June 1965, Lauritizen and Thayer 1966, USDA USFS 1969, Savage 1970, Tsukamoto and Wickersham 1970, Myers and Frasier 1974, Opp 1981). The objective of this article is to provide detailed instructions for construction of this guzzler design.

CONSTRUCTION

Size of the water catchment is based on annual rainfall and desired storage capacity. Yoakum et al. (1980:370) provides the following formula for calculating water yield:

$$(\text{sq m of catchment}) \times (9.9) = \text{l/cm of rainfall}$$

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[1]English units of measure are used in this article to facilitate purchasing of materials and construction.

The English unit of conversion is provided:

(sq ft of catchment) x (0.617) = gal/in of rainfall

The size described below is for approximately 5,000 gallon storage in an 8-in rainfall zone. The water catchment, supported by a wooden frame, is 20.4 ft wide by 40.3 ft long (822^2 ft), with the highest point about 5 ft above the ground (Fig. 1). One or more storage tanks sits at ground level beneath the catchment, with the drinking trough located about 30 ft away from it. Approximately 1.25 acres is enclosed by a 3-wire fence.

Fig. 2 presents engineering details of the water catchment. Fifteen 4 x 4 in posts provide vertical support to 3, 4 x 6 in horizontal support beams that run the entire length of the catchment. These beams are constructed of 2 overlapping 2 x 6 in boards. Two additional 4 x 6 in beams complete the outside perimeter of the catchment. These also are constructed of 2 overlapping 2 x 6 in boards. Eighteen 4 x 4 in joists form an internal grid to give final support for the 30 gauge galvanized roofing material. These joists are constructed of 2 overlapping 2 x 4 in boards. A snow fence constructed of 2 x 12 in boards is attached to the top surface along 3 outside edges of the catchment.

All lumber should be No. 2 post, timber, structural joists and planks according to grading rules for western lumber by the Western Wood Products Association. Either Douglas fir or ponderosa pine can be used and should be pressure treated for the full length by the penthachlorophenal method. All lumber is cut and framed so that all joints will be square and closed; no shimming is allowed in making joints. Nail heads are to be flush with the wood surface and unused holes are plugged with treated plugs.

The slope of the water catchment's surface should drop approximately 12 in. This allows water to flow directly into the gutter assembly, which is constructed of 4-in rain gutter, down spout, drain pipe, and end plates. The storage tank is located so that the water falls straight down. The galvanized roofing and rain gutter are primed and painted with 2 coats of flat, lusterless, anti-rust enamel to reduce visual impacts. A 36-in high hogwire fence is attached to the 4 x 4 in posts to keep animals out of the storage tanks.

Fig. 3 presents engineering details of the water storage and delivery system. Of the 4 guzzlers considered, 1 has 1 - 20-ft diameter bottomless tank, 1 has 2 - 15-ft diameter bottomless tanks, and 2 have 3 - 12-ft diameter tanks with bottoms. The bottomless tanks sit on a single concrete pad. Storage volume for each combination approximates 5,000 gallons.

Of the 4 guzzlers, the bottomless tank constructed of 14 gauge galvanized steel costs the least. It should have corrugations approximately 2.75 in wide and 0.5 in deep with a 0.5 in rolled rim. The concrete should be composed of Type II Portland cement, fine and coarse aggregates, and water to produce a dense, plastic, workable mixture. Specifications should conform to standards imposed by the American Society for Testing Materials. A 2-in galvanized pipe directs water from the storage tank to the drinking trough. A screened box constructed of 0.25 in mesh hardware cloth located at the inlet will prevent large debris from entering and clogging the pipe. A 2-in globe valve and galvanized tee with cap is installed from maintenance purposes. The 2-in pipe is reduced to 1.25 in for attachment to the drinking trough. A 650 gallon trough is used for a drinking unit. Either Powder River troughs or approved equals are recommended. The troughs should be washed, primed, and painted with 2 coats of flat, lusterless, anti-rust enamel. A 1.25-in float valve must be installed to regulate the water level and a frame constructed of 4 x 4 in posts is necessary to anchor the trough to the ground. Drinking units that are designed for use by domestic livestock must have safety features recommended by Wilson and Hannans (1977).

Both storage tank and drinking trough require an overflow to direct excess water away from the structure. The overflow, constructed of 2-in galvanized steel pipe, leads 12 ft away from the water holding structures and then is reduced to 1.25 in plastic pipe. The overflow for the storage tank has an additional 100 ft of length while the drinking trough has only 50 ft of added length. Both overflows can be laid so that their outlets converge within the fenced area, and any excess water can then create a small, wet meadow.

Although fences often hamper movements of game animals, they may be necessary to exclude use of the guzzler by domestic livestock and feral horses. The BLM uses a 3-wire fence to help reduce hazards to big game. The bottom smooth strand is 16 in above the ground while the middle and top strands are barbed for a maximum height of 44 in. Antelope passes described by Mapston and ZoBell (1972) also reduce problems for pronghorn. Gates are not part of the fence because people may use the fenced area as a corral for domestic animals. Our fenced area covers approximately 1.25 acres and is satisfactory for deer guzzlers, but pronghorn guzzlers should have at least 5 fenced acres (Jim Yoakum, pers. comm.). A ladder or narrow passageway along the fence will allow easier human movement and an explanatory sign should be installed to reduce potential vandalism.

Table 1 presents a list of materials needed to construct a large storage capacity guzzler. The costs of the first 3 guzzlers were:

Material	$ 9,511.09
Labor	9,161.45
Equipment	3,673.30
Total	$22,345.84

This equals $7,448.61 per guzzler for a job that was a multi-agency cooperative effort: BLM provided materials, NDOW provided labor supervision, and the Nevada Department of Forestry's Honor Camp crew did actual construction. A bid contract for construction of the fourth guzzler was awarded for $10,212.80 in 1983.

PLACEMENT

Knowledge of the water distribution pattern is important. Yoakum (1980:28) states that good quality pronghorn habitat on sagebrush-grassland steppes has water sources less than 3.2 km apart, fair quality habitat has water sources from 3.2 to 8 km apart, and poor quality habitat has water sources greater than 8 km apart. Kerr (1979:56) also rated the available water patterns for mule deer habitat. His divisions are less than 4 km apart, 4 to 6.4 km apart, and greater than 6.4 km apart. Mackie (1970:43) observed the greatest number of elk (Cervus elaphus) 0.4 to 1.2 km from water followed by less than 0.4 km and then greater than 1.2 km as the farthest distance during summer and fall. These requirements may vary with different geographic locations.

All existing usable water sources are identified and plotted on a map. Circles are drawn around each water source based upon the following formula:

Elk	1.2 km radius
Mule deer	3.2 km radius
Pronghorn antelope	4.0 km radius

An elk, deer, or pronghorn located between any 2 sources that are 2.4, 6.4, and 8.0 km apart, respectively, need to travel only half of that distance to water. Suitable habitat outside the drawn circles then becomes eligible for guzzler location. Animals will discover the new water sources as they use the project area during cooler and wetter portions of the year. Miscellaneous factors for final placement include (1) local precipitation patterns, (2) natural drainages where the guzzler could be washed out, and (3) natural ambush points for hunters.

SUMMARY

Several different guzzler designs have been built and reviewed in the literature (Roberts 1977, Yoakum et al. 1980). With different needs in mind, the BLM in eastcentral Nevada modified a basic design that the BLM had previously built in Utah

and Arizona. These guzzlers are the first of their size ever constructed in Nevada. Pronghorn, deer, and nongame species have been observed near the first 3 guzzlers since completion. Guzzlers provide a real opportunity for improving water distribution for wildlife in the Great Basin.

Acknowledgments: We thank the Cedar City, Arizona, Strip and Phoenix BLM District Offices for providing their unpublished specifications. M. Barber and R. Suminski provided valuable coordination during various phases of these guzzler projects, while J. Yoakum and staff of the Alaska BLM State Office provided helpful review of the manuscript.

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Table 1. List of materials needed to construct a large storage capacity guzzler for use by big game.

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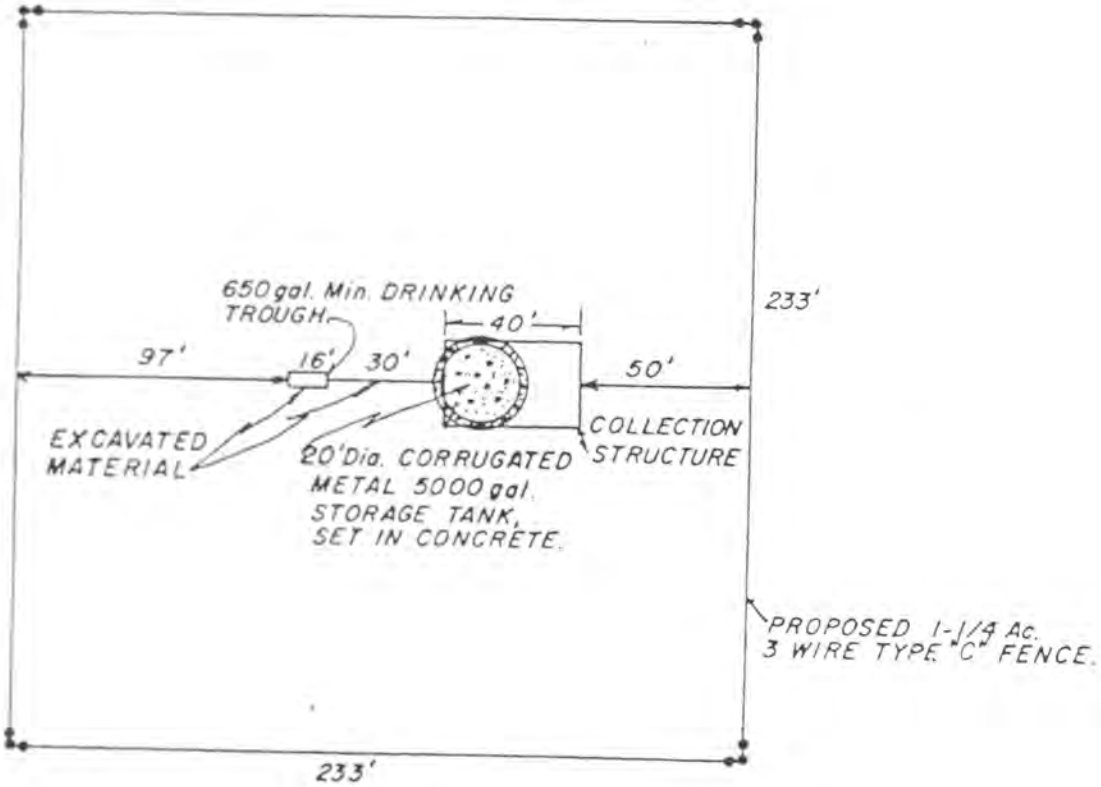
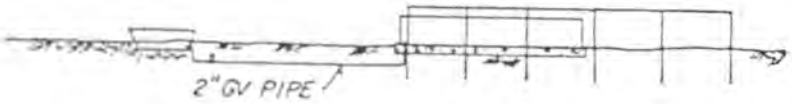
1. 4 x 4s: 22 x 8 ft
2. 2 x 4s: 36 x 9 ft-10.5 in
3. 2 x 6s: 320 LF
4. 2 x 12s: 100 ft-11 in LF
5. 4 in roof gutter: 20 ft (GV)
   A. Down spout: 1 ea
   B. Drain pipe: 1 LF
   C. End plates: 2 ea
6. 4 x 4 metal post tops: 59 ea (GV)
7. 36-in high hogwire: 121 ft.-4 in (GV)
8. 2 ft x 16 ft x 30 ga - CM roofing: 27.5 ea (GV)
9. 2 in x 2 in x 1/8 in Al. angle: 100 LF (5 - 20-ft sections)
10. Paint and primer: 1.5 gal ea (for GV roof)
    A. Paint to be dark brown
11. 20 ft dia CM 5,000 gal bottomless storage tank: 1 ea (GV)
12. Concrete, 23 ft dia x 8 in thick: 5 sac mix
13. 6 x 6 WWM or WWF for concrete: 415 sq ft
14. 650 gal drinking trough: 1 ea
15. 1.25 in float valve: 1 ea
16. 2 in GV pipe and fittings: 56 LF
17. 2 in globe valve: 1 ea, with water key
18. 8-in dia access box, "concrete" or "CMP": 2 ea
19. 1.25 in GV pipe w/fittings and 2 in x 1.25 in reducer: see drawings
20. 1.25 in PE pipe w/plastic to metal fittings: 150 LF
21. 2 in GV tee and cap: 1 ea
22. 0.25-in mesh hardware cloth "screen": 5.5 sq ft
23. Nails
24. 3-wire antelope fence w/bottom wire smooth and 22 ft tee post spacing: 932 LF (233 ft sides)
    A. No gates

NOTE: Lumber lengths are for Mill Run Lumber (i.e., 2 x 4 = 1.5 in x 3.5 in)



PLAN VIEW



SIDE VIEW

Figure 1. General view of large storage capacity guzzler for use by big game.

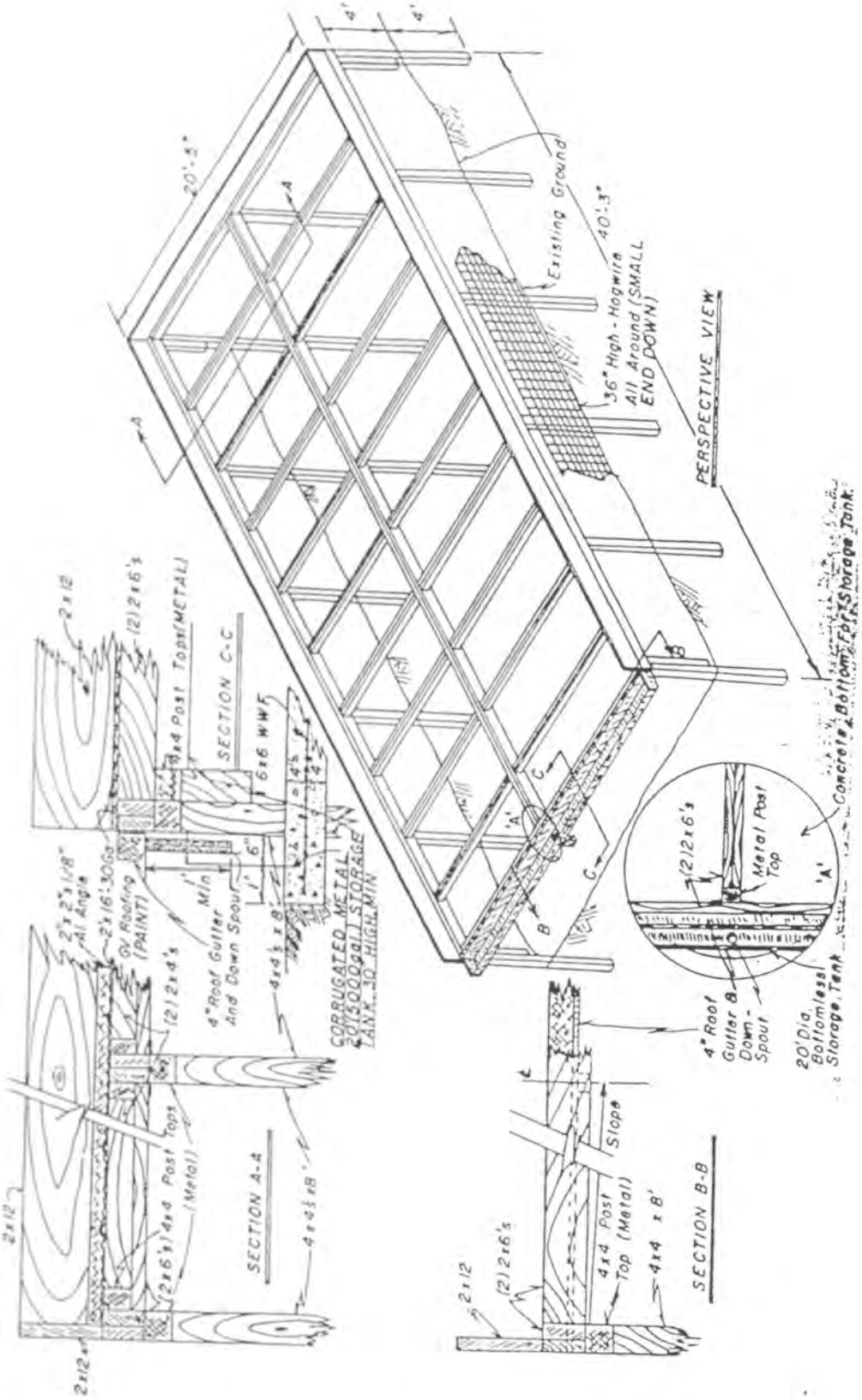


Figure 2. Engineering details of the water catchment.

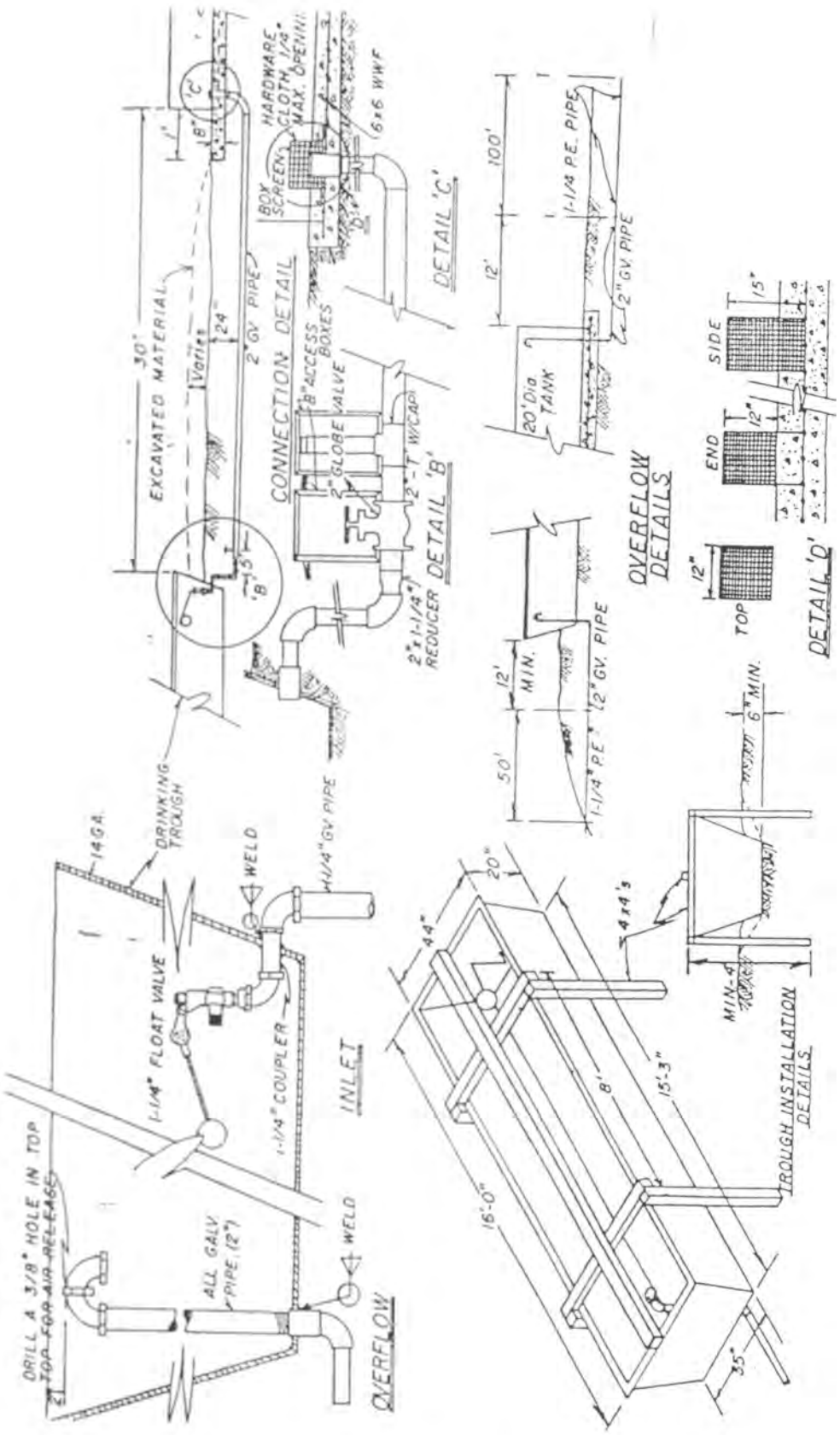


Figure 3. Engineering details of the water storage and delivery system.

ADDITIONAL CAPTURE METHODS AND HABITAT SUITABILITY CRITERIA FOR PRONGHORN TRANSLOCATIONS

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Abstract: The objective of this paper is to provide additional information to supplement the guidelines on "Trapping and Translocation" requested by delegates to the 13th Pronghorn Antelope Workshop. Clover traps have been used to take pronghorns with salt appearing to be the preferred bait. Net guns seem to be the tool of choice for capturing small numbers of pronghorns, especially when animals are scarce, certain age or sex classes are needed, or access is difficult in the capture area. However, mortality in excess of 20% has been reported from some capture attempts. Chemical immobilization of free-ranging pronghorns generally results in high mortality. Carfentanil and Rompun is probably the best drug combination available for pronghorns. Translocations should only be attempted when good-quality habitat is available to support a population of 200-500 pronghorns. Every translocation effort should include a feasibility study, preparation phase, release or introduction phase, and a follow-up phase. Suggested criteria to be considered in evaluating translocation sites are presented.

INTRODUCTION

The objective of this paper is to provide information on capture methods and habitat suitability criteria for pronghorns as requested by the Pronghorn Antelope Workshop delegates. Information on capture practices will first be reviewed, followed by several methods for evaluating suitability criteria for choosing translocation sites.

"Guidelines for the Management of Pronghorn Antelope" (Autenrieth 1978) was published as part of the proceedings of the 8th Pronghorn Antelope Workshop. The objective of the guidelines was to provide pronghorn (Antilocapra americana) managers with the best information available for managing and perpetuating pronghorns and their habitats. The need to revise and incorporate new information was recognized at the outset.

The first Supplement to the Guidelines, "Trapping and Translocation," (McKenzie 1984) was published as part of the Proceedings of the 11th Pronghorn Antelope Workshop. The Guidelines and the Supplement were printed and distributed by the Texas Parks and Wildlife Department in 1983.

At the 13th Pronghorn Antelope Workshop in Oregon (1988), participants urged that trapping and translocation be expanded to include more techniques for capturing pronghorns and, especially, how to choose suitable sites for translocations. McKenzie (1984) had concentrated on the two most-used capture methods--the corral trap and linear tangle net. In this paper, we concentrate on other less-used, but sometimes useful methods. In addition, we have surveyed the literature regarding translocations and report on different criteria to use when choosing relocation sites because we believe this is one of the most important considerations in any translocation operation.

RESULTS AND DISCUSSION

Clover Trap

Two adult pronghorn does were caught in clover traps in Oregon (M. Willis pers. comm, 1988). The traps were pre-baited with alfalfa hay and salt (salt seemed to be more effective). One doe lost approximately half her pelage but apparently suffered no permanent damage despite cold weather. Several other pronghorns were observed in the trap, but the drop panel was frozen open. If the panel had not frozen, trapping success would have been three trap-nights per animal.

Net Gun

Net guns have been improved during recent years, with 4-barreled guns and square nets largely replacing the 3-barreled prototype guns and triangular nets.

Barrett et al. (1982) concluded pronghorns are captured easily with the net gun; however, considerable effort may be required to reduce capture myopathy and losses from trauma. Eighteen adult pronghorns were captured successfully using a 3-barreled net gun during three capture operations in Colorado (Firchow et al. 1986). A total of 32 shots were fired--20 to capture 18 pronghorns on successful attempts, and 14 during unsuccessful attempts. Mean group size for successful captures (6.2) was less than the mean group size for unsuccessful attempts (11.2); and handling time for captured animals averaged 6.2 minutes. Two of 20 pronghorns (10%) captured, or pursued for capture, died. One animal fell during hazing and broke its leg; the other fell and broke its neck when tangled in the net. Five females captured during March and April were pregnant and carried fawns to full term.

The net gun technique worked best on small groups of pronghorns (Firchow et al. 1986). Groups of 12 or more remained bunched and a clean shot for a single animal was difficult to make. Lone animals or pairs dodged and darted under the helicopter, making capture difficult. Only one animal was

captured from each herd. The authors suggested ways to reduce stress- and injury-related deaths. Initially, they used 12 minutes as a cut-off point for hazing animals but switched to a 7-minute maximum after signs of stress were noted in animals during the first capture operation.

Arizona Department of Game and Fish personnel used the net gun to capture Sonoran pronghorns near the border of Mexico (Ray Lee pers. comm. 1988). They mounted a video camera above the gunner's head. This allowed the gunner to later evaluate his performance and aided in the training of new gunners.

Fish and Game personnel in California net-gunned 19 pronghorns with 4 (21%) mortalities. The first 2 mortalities (broken necks) occurred under what appeared to be ideal conditions. The animals were running uphill in 6-8 in. of snow (Bill Clark pers. comm. 1990). Clark noted that placement of the net may be important. If the net is placed far enough in front of the animal that its front feet immediately entangle, the animal generally goes down without problems. O'Gara noted the same thing. If a net just goes over the head of an animal, then the hind legs will tangle but the animal will not go down, and the danger of breaking a hind leg is great. In that case, the best thing to do is immediately shoot another net over the entangled animal with at least half of the net falling in front. However, other gunners have noted the rapid tumble of a pronghorn that tangles immediately can result in a broken neck--the most common cause of mortality with this method.

O'Gara sometimes nets 2 or even 3 Rocky Mountain goats or bighorn sheep at a time with the 4-barreled net gun. However, when this practice was used on pronghorns (2 double captures), the animals lost unacceptable amounts of hair and skin during the falls, and one suffered a broken leg. When 1 pair of pronghorns fell at full speed, the forces exerted on one another caused the thin nylon netting to scrape and cut like a knife. O'Gara later successfully captured does from large, wintering herds in Montana by netting separate does running ahead of the bucks that brought up the rear of the herd. In this case, the helicopter remained low behind the herd, and the top projectiles of the gun were seated deeper than bottom ones so the top projectiles would travel faster and the leading edge of the net would fall ahead of the target doe on the comparatively long shots. If the helicopter flew over the bucks for closer shots down on the does, the entire herd would scatter and dodge, making shots difficult, until the herd reassembled. O'Gara found 7-inch-bar measure nets best for pronghorns.

Twenty pronghorns (13%) died during 151 recent captures (Bill Clark, Ray Lee, Bob Watts, and Mitch Willis pers. comm. 1990). More than half died from broken necks, some were

destroyed because of broken legs, and 2 died about 2 wks after capture--apparently from capture myopathy.

The net gun may be the tool of choice for capturing small numbers of pronghorns, particularly if few animals are in an area, if certain age or sex classes are needed for radio-collaring, or if the capture area is difficult to reach by land-based vehicles. Gunners should receive training with the net gun before attempting captures and should net only 1 animal per shot.

Chemical Immobilization

Pronghorns seem to have a narrow tolerance to most immobilizing drugs. Occupying open country, pronghorns are especially difficult to drug with darts. Having thin skins, small muscle masses, and slender, fragile bones, pronghorns are also susceptible to injury from darts.

The first drug used to immobilize pronghorns from a distance was succinylcholine chloride, but tolerance of pronghorns to the drug is low, and Amstrup and Segerstrom (1981) stated it should not be used.

Etorphine hydrochloride (M-99) is fast acting, and its effects may be reversed quickly with diprenorphine hydrochloride (M50-50). M-99 worked well on captive pronghorns, but at least 5-ml darts (weighing about 16 g) were required for remote injection--such darts are too heavy for fragile pronghorns.

Carfentanil citrate has produced satisfactory results on pronghorns when mixed with Xylazine hydrochloride (Rompun). Two mg of Carfentanil was mixed with 33 mg of Rompun in a 1-ml Capchur dart (O'Gara 1987). Five mature pronghorn bucks injected with this mixture on the National Bison Range in Montana were immobilized between 2.2 and 6.8 min. after injection. The use of small, 1-ml darts achieves good accuracy even with a light charge and reduces the risk of tissue damage from impact. Injection from a small dart also creates less tissue damage and complete discharge is more assured than with a larger amount of solution. Two bucks injected with 3 mg of Carfentanil without Rompun failed to go down or went into an excitement phase before going down. M50-50 acts as an antagonist to Carfentanil. O'Gara administered 4 mg of M50-50 per mg of Carfentanil intramuscularly upon first handling an immobilized animal, and the same dosage was administered intravenously immediately before release. Another antagonist, Naloxone hydrochloride, is now available and is administered at 100 mg per mg of Carfentanil. Three of 5 pronghorns, immobilized with Carfentanil and Rompun during 1988, died after reversal with Naloxone. The reasons for 2 deaths were not determined, but 3 were apparently related to chases by rutting bucks. Naloxone should be carried whenever using drugs

that are dangerous to humans--it is the drug used in emergency rooms to reverse drug narcosis.

Telazol is now available in the United Stated on an experimental basis. Nothing has been published concerning its use on pronghorns, but Bill Lance (pers. comm. 1990) reported satisfactory immobilization of pronghorns with 13 mg of Telazol per kilogram body weight. Such a dose would require a 2-ml dart--bigger than desirable for pronghorns. O'Gara has broken femurs of pronghorn bucks with 2-ml darts propelled by light (green) charges from a distance of 30 m.

Nothing is known concerning the effect of immobilizing drugs on fetuses of does immobilized during late pregnancy, but attempts should not be made to immobilize pronghorns during the rut. As soon as a doe becomes unsteady on her feet, bucks in the area will attempt to breed her. This can result in an extended, fast chase and the death of the doe. When a buck becomes unsteady, other bucks attempt to kill him. If they do not succeed outright, the exertion can still result in death of the drugged buck. O'Gara observed bucks running as far as 2 mi (3.2 km) at top speed to breed or fight an unsteady animal.

If one must dart pronghorns, Carfentanil and Rompun are probably the best drug combination available today. For helicopter work, the net gun seems safer and more efficient than drugs.

Choosing Translocation Sites

Translocation should be considered only after it has been determined pronghorns can survive in a habitat possessing sufficient forage, water, and space in historic rangelands and not in conflict with other environmental issues (McCarthy and Yoakum 1984). The translocation should be preceded by a feasibility study or management plan to document the objectives, translocation procedures, and post-release monitoring of the animals and their habitat.

At times, sportsmen's organizations, conservation groups, or local governments recommend translocating pronghorns into areas not capable of sustaining herds. Such endeavors resulted in the loss of all animals transported to Florida and Hawaii. Analysis of these 2 cases disclosed the proposed sites did not meet pronghorns' habitat requirements. Ignoring such basic biological requirements results in the eventual death of translocated animals, high expenditure of public funds, and a negative reaction by the public to the integrity of wildlife managers (Yoakum 1978). Similar unsuccessful translocations have been made in Mexico and the United States, partly because of excess animals causing crop depredations.

One of the first procedures for determining the potential suitability of an area for translocation was developed by the Colorado Department of Wildlife (Hoover et al. 1959). Twenty-eight years later, the International Union for Conservation of Nature and Natural Resources (1987) proposed almost the same criteria and summarized them as a feasibility study, preparation phase, release or introduction phase, and a follow-up phase. The latter often has been neglected, and the feasibility studies and preparation phases have been inadequate in many cases.

Management Plans: The trapping and translocating of pronghorn is one of the major management practices accomplished for these animals in modern times. Such practices involve large amounts of manpower, time, and finances; therefore, it is recommended that feasibility studies or management plans be developed prior to releases. These plans should provide detailed procedures for capture, transportation, and release in new habitats.

Management plans should specify capture methods, numbers of animals needed, and specific release sites. Details should be provided on procedures to capture animals as safely as possible. A veterinarian at the capture site is highly desirable. The plan should also provide particulars regarding methods of release and follow-up monitoring evaluations.

Translocation goals should address the question of establishing a viable herd. A viable herd is defined as a population that increases in numbers during more years than it decreases. Relocated herds that increase 20 to 30% within 5 to 10 yrs after release are indicative of a herd that is responding to suitable habitat conditions. Franklin (1980) considered 50 breeding adults the minimum for a population size. It, therefore, seems reasonable that translocations should contain 50 to 100 animals as recommended by Hoover et al. (1959). Franklin also suggested 500 randomly mating individuals as the minimum population size for sustaining genetic variation at a level to enable the species to adapt to changes in the environment. This appears appropriate for pronghorns, especially on rangelands experiencing frequent severe winters or numerous droughts.

Determining Suitability of Release Sites: One initial factor to be evaluated for a release site is whether the area was historically occupied by pronghorns. Sites not historically inhabited seldom support viable herds as experienced with the translocations to Hawaii and Florida. Should a proposed release site not be presently occupied, the following must be ascertained: What caused the animals to become extirpated; whether the factor or factors responsible for their elimination still exists; if the habitat or other conditions have been altered sufficiently to not meet the pronghorn's habitat requirements; and whether current land uses favor reintroduction.

Translocations were one management technique that aided populations to increase from 25,000 in 1924 to over a million in 1984 (Yoakum 1986). Of the hundreds of translocations during the 50 yrs, there are many reports of successes (Russell 1937, Fisher 1942, Thompson 1947, Stokes 1952, Hoover et al. 1959, Menzel and Suetsugu 1966, Yoakum 1978, and Britt 1980); however, some were unsuccessful (Aguirre and Sotomayor 1981, Tsukamoto 1983, McCarthy and Yoakum 1984, De Monte and Kathman 1984). Improved techniques and knowledge from past experiences provide guides for future operations. Following are 3 examples:

Feasibility Guide: Hoover et al. (1959) developed criteria for selection of translocation sites in Colorado. Eight of those criteria bear repeating with only slight modifications 30 years later.

1. Unless sufficient continuous rangeland is available to allow a translocated herd to expand, the site should be rejected. As a rule, each animal requires at least 1^2 mi (1.6 kms) of native grassland, and the number of animals should not be less than 100.

2. Pronghorns feed primarily on forbs and shrubs, therefore, a good variety and production of these should be present. Rangelands in poor condition or dense shrublands are not desirable.

3. Concurrent use of rangelands by domestic livestock (cattle, horses, sheep) should be evaluated. This involves competition for forage as well as compatibility, construction of fences, and predator control practices.

4. Depredation problems to agricultural crops is a potential that likewise needs evaluation. Isolated fields surrounded by rangelands usually are subject to more depredation than are numerous fields.

5. A map illustrating the land ownership pattern should be prepared, especially if private lands are involved. Public lands are preferred, followed by large blocks of private lands under one ownership. The least desirable sites are private lands in small units with many owners.

6. Reactions of many people to an introduction should be considered, particularly those of local conservation organizations, personnel charged with administering public lands, and private landowners. It should be learned whether those landowners would be agreeable to releases, especially relative to hunting seasons.

7. If all the above factors are satisfactory, written permission should be secured from all public land agencies and private landowners in the area for the release.

8. Provide for alternate release sites in the management plan to allow for inclement weather, road conditions, etc.

As a guide for determining an appropriate release site, Hoover et al. (1959) developed a form recommended for completion prior to release on grasslands. Yoakum (1980) adapted the form for shrub-steppes (Table 1). The forms warrant attention from managers planning translocations.

Habitat Suitability Criteria: Suitable habitat for pronghorns is related to the right amount and juxtaposition of all habitat characteristics meeting the species' habitat requirements. Too little or too much of any biotic or abiotic factor may become the primary component limiting production and survival. Knowledge of these habitat requirements becomes the ecological foundation for managers making translocation decisions (Yoakum 1980).

Habitat suitability was used as part of the criteria for evaluating five potential translocation sites in Mono County, California (McCarthy and Yoakum 1984). The strategies for evaluating these sites may have applicability in assessing other potential release sites, to establish priorities and to provide insight into the feasibility of a transplant.

Procedures for choosing the best 5 sites included an evaluation of these 9 criteria:

1. Habitat suitability was evaluated for water, vegetation quality (percent of forbs, shrubs, and grasses), forage quantity, and vegetation height using criteria established by Yoakum (1980).

2. Mean winter snow depths were interpolated using data from weather stations. Areas were considered suitable for winter use if snow depths were less than 10 in (25 cm).

3. Natural physical barriers were evaluated to determine potential for restriction of pronghorn movements. Major physical barriers included large ravines, mountain ranges, and dense shrub or timbered areas.

4. Area size was determined by using a polar planimator and 7.5 min (U.S. Geological Survey quad maps. Optimum area size was considered 100^2 mi (259 km^2).

5. Livestock fences were evaluated in relation to pronghorn passibility. A fence was considered passable if the bottom wire was at least 16 in (41 cm) from the ground.

6. Potential for predation was subjectively rated in terms of high, moderate, or low. Predator abundance information was obtained from various government agency personnel, ranchers, and individuals familiar with the sites.

7. Potential for crop depredations was estimated on the basis of agriculture crop location in relation to each site. Distances were determined to the nearest alfalfa field, and a depredation potential rating of high, moderate, or low assigned to each area.

8. Seasonal suitability was evaluated on the basis of whether or not an area could support pronghorns on a year-long basis.

9. Potential for competition with livestock was estimated on the basis of class of livestock, animal unit months, and grazing systems. Each site was rated as having high, moderate, or low potential for livestock/pronghorn conflicts.

Following the evaluation of each site, limiting factors were addressed on the basis of the above criteria. The sites were compared with each other and prioritized in terms of the site(s) that had the greatest potential for a successful pronghorn transplant. This system provided 2 components to help select the best potential release site. (1) Based on ecological data collected in the field, a numerical rating was achieved denoting the site with the highest potential; and (2) limiting factors were identified that could be improved prior to releases, providing a better chance for a successful translocation.

Viability index: A viability index was developed specifically for evaluating pastures in southwestern New Mexico as translocation sites. The pastures were fenced with net wire that created barriers to movements of pronghorns (U.S. Bureau of Land Management 1986). Pasture suitability was based on the relation of a set of variables--fall forbs, topography, pasture size, and numbers of domestic sheep--which, when incorporated in a formula, must total 1.5 for a pasture to be considered suitable for a pronghorn translocation. The formula is:

$$\text{Viability index} = 1.082 + (0.106)(X^2) - (0.068)(X^3) - (0.059)(X^4), \text{ where}$$

X^1 = the number of forb species during the fall

X^2 = ruggedness index

X^3 = pasture size in sections

X^4 = anticipated average domestic sheep stocking rate (animal units per section where 1 animal unit = 5 sheep)

The coefficients in the formula were derived from data collected during a 4-yr study near the Roswell Resource Area (Howard et al. 1990). The coefficients were weighted to the relative importance of each variable (X^1, X^2, etc.) in the formula.

In conclusion, the following guidelines are recommended for pronghorn translocations:

1. Translocation sites should be evaluated for habitat suitability prior to capture of animals. Each state or province should establish a rating system considering local conditions. Areas that do not meet such specifications should not be considered feasible until conditions are made to meet all criteria.

2. Multiple translocation sites should be prioritized to establish which areas have the highest potential for successful translocations. Ideally this should be done on a statewide, province-wide, or regional basis to assure that translocations are made only into high-quality sites.

3. Habitat suitability criteria should be fine-tuned for site-specific release areas. Ratings for vegetation and water quality and quantities should be modified to reflect ecological conditions within a state, province, or region.

4. Translocation projects should include monitoring to determine success after animals are released. This is important in developing and modifying translocation guidelines and ensuring accountability in translocation endeavors.

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PRONGHORN ANTELOPE SURVEY EFFICIENCY IN MONTANA

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Abstract: Between July, 1985 and April, 1989 the accuracy of Montana's summer, aerial antelope survey technique was tested using marked, individually recognizable females. Sixty-three females within the Yellow Water Triangle area of Hunting District 420 were fitted with radios or neck-bands. Twenty-eight complete coverage surveys were flown following our standard criteria. It is determined that we have been flying at the poorest time of the year for determining an accurate population estimate. It is recommended that we phase out our current July surveys and begin surveying in winter or spring.

The primary objective of this study was to evaluate Montana's current aerial antelope survey technique and make pertinent management recommendations.

The antelope management objective for most administrative regions of the Montana Department of Fish, Wildlife and Parks is to harvest the maximum sustainable yield from the populations. Accurate monitoring of antelope population levels is paramount to this objective. Our primary technique is a summer aerial population survey. These aerial summer surveys were initiated in the early 1940s and, with minor modifications, have continued to the present.

Although not completely standardized in all parts of the State, the following list details the criteria followed while conducting antelope surveys.

1. An antelope Hunting District is the unit of survey. Some of the antelope Hunting Districts in the State are thought to encompass actual population units. Most often the Hunting Districts are geographical units and probably do not encompass actual antelope populations.

2. A wildlife biologist is responsible for the survey.

3. We use a fixed-wing, Piper Super Cub or a similar one-passenger plane flown at 300 ft or less, depending upon the time of day and the terrain. The pilot, normally a non-Department person, is contracted for flying and is not directly responsible for helping with the survey. Depending upon the pilot's experience, he usually navigates the flight and assists in counting.

4. The surveys are normally made during July. Early August has been considered acceptable, but the data is needed for adjusting the final either-sex hunting quotas before mid-August.

5. The surveys are in the morning, beginning about one-half hour after sunup. This is approximately the time when the sun gets above the wing and no longer reflects through the windows during level flight. We continue until antelope are lying down because of rising temperatures or until the plane runs low on gasoline; about 4 hrs. Evening flights have been considered acceptable, but not preferred.

6. It is preferably cloudless during the surveys. Complete cloud cover is unacceptable. Many surveys are made at some condition between the extremes.

7. The survey makes complete coverage of the antelope habitat within a Hunting District by flying north and south at one-mi intervals while working from east toward the west. Evening flights, if necessary, are flown working from west to east to take advantage of the direction of the sun.

8. Every effort is made to keep from recounting antelope that move into the unsurveyed areas.

9. All antelope are recorded as to location, sex, and age. Males are most often recorded as yearlings or adults.

The Yellow Water Triangle area of antelope Hunting District 420, southwest of Winnett, was selected as the site for study. Pyrah (1987) recently completed a long-term study of antelope ecology on the same area. Pyrah had delineated population boundaries and herd and doe band parameters which were invaluable for dispersing the markers for this study. The habitat and topography of the Yellow Water triangle, described in detail by Jorgensen (1979) and Pyrah (1987), were felt to be typical of much of the rangeland antelope habitat in central and eastern Montana.

Because of group sizes, social behavior, and habitat selection, it was decided to mark female antelope only. When possible, males were counted during the surveys; but, as expected, numbers were somewhat erratic. It would take a much more time-intensive effort to accurately develop population estimates for males.

METHODS

Forty-six female antelope were captured with a hand-held, 4-barreled, net gun fired from a Bell 47G-B2 helicopter during July, 1985. Ten were given individually recognizable neck bands. The 4-in wide Richy brand neck bands of a rubber-like material were of 8 different background colors with various contrasting symbols. Twenty-nine received radios attached to the same visually recognizable neck bands. Three inadvertently captured fawns were ear tagged, and 4 females died, presumably with broken necks. The 39 individually recognizable females were approximately 10% of the estimated number of females on the area.

The capture technique which was previously untried with antelope and largely a success, deserves brief mention for further reference. The helicopter carried 3 people; the pilot, the gunner, and the biologist. Because of the manpower limitation for constraining the netted antelope, no more than 2 were netted at 1 shot; and, when possible, only one. Within the study area of about 200 sq. mi, we were able to mark at least 1 antelope in each of the 16 doe band areas identified by Pyrah. Antelope were captured at a rate of 10 per hour of flying time. Of the 42 antelope captured and released, 2 died within 2 wks, presumably related to our handling. It is assumed they developed lactic acid problems.

In March, 1986, 2 more female antelope were radioed and 14 neck banded for individual recognition. One additional antelope died, presumably from a broken neck. None were known to have died from injury after release. In August of 1987, 8 additional female antelope were neck banded using a Hughes 500 Helicopter. One additional female died of a broken neck. The inexperience of a different pilot made this effort inefficient and costly. The effort was terminated before placing the desired number of markers, but the marked females in the population still remained at about 10% of the female estimate. Appendix Table 1 details pertinent information related to marked antelope.

Complete coverage surveys following our standard criteria began shortly after marking in July, 1985, and continued into April, 1989. I utilized 2 pilots for surveys, both having about 10 yrs of previous antelope surveying experience. No consistent pattern of difference was noted between the pilots, thus this was not considered a variable to be analyzed separately. All surveys were with a Piper Super Cub PA-18. Complete surveys of the area were flown during all seasons.

All 12 summer surveys were made under ideal conditions. All flights were cloudless, mostly calm, and during the morning. Two late summer surveys (late August) were flown under ideal conditions. Four winter (before March 15 and any green-up of spring vegetation) surveys were made under clear skies and with

no snow. Two additional winter surveys were made when it was cloudy and with scattered or patchy snow conditions. These 2 were picked to be under "poor" conditions. No winter flights were made under what was felt to be ideal conditions of clear skies with complete snow coverage. Because of herd size during the winter, I used a 35 mm camera. A video camera proved too cumbersome in a super cub. No attempt was made to classify wintering antelope into sex or age categories.

I made 5 surveys under clear skies with good green-up conditions in April and early May. The April 1989 survey was not used for all determinations of survey efficiency because the fate of several marked females is still uncertain. One additional spring survey in late March was conducted with poor light conditions under cloudy skies, and without sufficient green-up.

Two October surveys were completed under good conditions. Fawns and does were not recorded separately in fall or spring surveys although bucks were recorded separately.

I recorded all markers observed, markers missed, and those counted more than once. Recounting previously observed antelope was a much larger error than previously considered. This appeared to vary with the number of herds counted and was thus more of a problem during the summer than at other seasons. The effort put into not recounting became more intense than for our "normal" surveys, probably creating some bias. The percentage of the observed, marked antelope that were counted 2 or more times on a single survey varied from 0 to 32%. I believe our effort for "normal" surveys is to keep track of counted antelope that move into the unsurveyed area at least through the next 1-mi strip. During this study, it was found that previously counted antelope regularly moved 3 to 6 mi into the unsurveyed area, often ending in herds with different numbers and composition than when first recorded. Density estimates during the period of this study varied between 3 and 5 per sq mi. Actual survey densities on some of our rangeland Hunting Districts regularly range from 10 to 15 per sq mi. The recounting error at these densities is, no doubt, a much bigger problem than previously thought.

The markers missed during the survey were normally searched for after the survey to see if they were on the study area. The initially large number of radios facilitated this effort. With time, familiarity with home ranges enabled the relocation of most missed antelope with neck bands only. It was originally hoped that the radios would provide insight into why an antelope was missed during the survey. This effort was largely unsuccessful because of the unexpected size of movements during the time of the survey (as great as 6 mi between re-observations). The exception (discussed later) was during winter surveys when I often failed to see the markers, but counted the antelope.

RESULTS

The data from the 28 surveys will be looked at in several ways for the purpose of determining the efficiency of our "normal" surveys. None of the ways significantly change the final conclusion, which is: our "normal" summer period in July and early August is the poorest time of the year to accurately determine a population estimate. Appendix Table 2 contains the pertinent data for each of the surveys.

The number of marked females varied between 5 and 10% of the estimated female population over the period of the study. Basing survey efficiency purely on the percentage of markers observed, seems one straight-forward approach to determining survey efficiency. Table 1 shows a summary of 27 usable surveys by season, percent observability, and range of observability.

Table 1. Seasonal antelope survey efficiency based on percent of marked antelope observed.

Season	No.of Surveys	Percent of markers Observed	Percent Range of Observability
Surveys with good conditions			
"Normal" summer July-Aug 15	12	60	40-79
Late summer Aug 15-Sept 1	2	83	83-84
Fall	2	89	87-91
Winter Dec 1-Mar 15	4	90	82-96
Spring Green up-May 1	4	78	71-89
Surveys with poor conditions			
Winter	2	68	58-78
Spring	1	67	

This approach to determining survey efficiency can potentially be fine-tuned by developing a population estimate that considers markers counted 2 or more times. A marker was only recorded as observed more than once if it would normally have been counted as a new, previously uncounted antelope in an

unmarked sample. I made this decision prior to approaching close enough to observe any markers. As an example for developing this estimate: I counted 200 females, including those counted 2 or more times; observed 20 of 30 markers, but observed 5 of the 20 twice. Therefore, an estimate is 240 females based on 25/30 of 200. This is further fine-tuned by accounting for marked females that my decision was not to count because it was thought they were previously counted. In the "normal" surveys they would not have been counted, but the marker prevented a wrong decision. These errors act the opposite of the example described above. Table 2 shows the estimate developed in the above way as Estimate No.1.

Table 2. Data from aerial antelope surveys in H.D. 420 for testing the efficiency of Montana's aerial survey method. Both Estimate No 1. and the Preferred Estimate are estimates of the sex or age classes in parenthesis.

	Survey Numbers								
Date	Yrl. Male	Ad. Male	Fem	Fawn	Total	Percent of Markers Observed	Percent Duplicates	Estimate No.1	Preferred Estimate
1985									
7/26	22	87	(383)	134	626	25-33 (76)	8-33 (35)	407	411
8/18	48	94	(369)	118	629	30-36 (83)	2-36 (6)	415	411
10/17	40	75	(486)		601	27-31 (87)	2-31 (6)	522	553
1986									
1/13					(1013)	23-28 (82)	4-28 (14)	1055	1055
4/1	61	96	(607)		764	40-45 (89)	4-45 (9)	619	619
5/1	77	98	(448)		623	33-41 (80)	1-41 (2)	546	546
7/8	40	80	(314)	148	582	30-41 (75)	1-41 (2)	403	430
7/16	40	48	(340)	157	585	19-38 (50)	6-38 (16)	515	430
7/25	31	48	(221)	120	420	20-37 (54)	1-37 (3)	388	430
8/5	56	49	(266)	131	502	18-37 (49)	0	543	430
10/22					(660)	29-32 (91)	3-32 (10)	653	680
12/1					(502)	21-27 (78)	0	644	680
12/24					(740)	24-25 (96)	2-25 (8)	712	680
1987									
1/23					(650)	22-24 (92)	3-24 (13)	619	680
3/25					(477)	16-24 (67)	0	712	680
4/6	65	60	(475)		600	18-25 (72)	5-25 (20)	565	565
7/15	73	58	(316)	147	594	12-24 (50)	0	632	430
7/27	47	61	(272)	134	514	15-24 (63)	1-24 (4)	432	430
8/4	67	52	(337)	124	580	19-24 (79)	0	427	430
8/28	71	62	(368)	155	656	26-31 (84)	1-31 (3)	423	430
1988									
1/18					(519)	15-23 (65)	1-23 (4)	746	650
2/25					(575)	24-24 (100)	1-24 (4)	552	650
4/15					(507)	20-25 (80)	0	634	650
7/16	40	49	(245)	102	436	14-24 (58)	1-24 (4)	392	450
7/2	50	43	(247)	117	457	13-24 (54)	0	456	450
7/28	48	50	(213)	119	430	10-25 (40)	0	532	450
8/5	62	57	(312)	131	562	16-24 (67)	0	468	450
1989									
4/12	91	73	(525)		689	17-?	0	-	525

The above estimates seem reasonable, but it can be argued that an error can only be considered an error and should not be used to offset errors of another type. As an example: I observed 19 of 38 markers, counted 6 of the 19 twice, and decided not to count 1 marker thought to be counted earlier, but not. The total counting error becomes 26/38 or 68%. I do not consider this approach to be a realistic way of interpreting the data.

Another approach, and that approach originally intended for use, was a Lincoln Index for calculating population estimates. In the range a Lincoln Index expresses for population estimates, the low value is often below that number of antelope actually counted. The number of marked animals was apparently inadequate and, as with many biological studies, a larger sample was impractical. I do not consider the Lincoln Index as giving a pragmatic range of estimates.

Preferred Method of Estimate

I believe that estimates No. 1. developed in Table 2 are reasonable. With an arithmetic approach, the estimate can be refined. Yearly recruitment and hunter mortality on the area is known, and with this refinement I have been able to develop the Preferred estimate also shown in Table 2.

Table 3 shows harvest estimates for the study area based upon Pyrah's determination that it is 75% of the questionnaire estimate for Hunting District 420.

Table 3. Antelope Harvest in the Yellow Water Triangle.

Year	Number of Either-Sex Permits	Males	Females
1985	200	56	19
1986	300	100	44
1987	300	74	44
1988	300	68	44

Please refer to Table 2 for an example used for developing the Preferred estimate. The 2, 1985 summer surveys became the base data. Estimate No.1 indicated 407-415 females which I called 411 females for the preferred estimate. Females and fawns could not be separated during the fall 1985 surveys, and the estimate is for total females and fawns. An average of 126 fawns were actually counted during the 1985 summer flights, and I assumed they are seen at the same rate as females. Therefore, estimate No.1 for fawns during the 1985 summer is 142. I added the 142 fawns to the 411 females for the 1985 fall preferred estimate of 553 females and fawns. With minor rounding of

numbers, the above example explains how the preferred estimate was developed for other seasons and years.

Two survey estimates, January and April, 1986, are far from an expected arithmetic estimate. A sod busting effort eliminated approximately 7,000 acres of antelope winter range in Hunting District 530 to the east of the study area. The January, 1986, survey reflects displaced antelope which stopped on the nearest suitable habitat. The April, 1986, survey reflects some of the displaced antelope still lingering on native rangeland to the west of their normal area.

Table 4 summarizes the percent of the Preferred estimate that was actually counted in 28 surveys and shows the range of variation in survey efficiency.

Table 4. Seasonal antelope survey efficiency based on the percent of the Preferred population estimate actually counted.

Season	No. of Surveys	Percent of the Preferred Estimate Actually Counted	Range of Estimate
Surveys with good conditions			
"Normal" summer July-Aug 15	12	66	49-93
Late summer Aug 15-Sept 1	2	88	86-90
Fall	2	92	88-97
Winter Dec 1-Mar 15	4	97	88-109
Spring Green up-May 1	5	88	78-100
Surveys with poor conditions			
Winter	2	77	74-80
Spring	1	70	-

Although not a direct objective of this study, it seems important to point out other possibly significant data in Table 2. Weather conditions during the study were dry, but with mild winters, and there was no obvious unusual mortality. According to the Preferred estimate, the number of females significantly

decreased from the time of the green-up survey in April or May and the start of summer surveys in early July.

Year	Female estimate in Spring	Female estimate in July
1986	546	400
1987	565	430
1988	650	450

These spring losses were about a third of the female population each year and cumulatively add to more than 470 females for the three years. This compares to an estimated legal hunter harvest of only 135 females for the three years. Although not completely quantified, I am confident the loss was dispersal from the population. Limited data from the marked females supports this conclusion. This dispersal occurred at densities of 2-2.5 females per sq mi. Two marked females actually dispersed 40 mi to the north and settled in an area with a total density of 15 antelope per sq mi.

Pyrah (1987) reported a female density of approximately 5 per sq mi was the optimum density for the Yellow Water Triangle. He discussed a significant unexplained loss of females occurring at 3-yr intervals, independent of density. This data would suggest that his losses were probably due to dispersal.

CONCLUSIONS

The conclusions derived from Table 4 are not different than those from Table 1.

The spring 1987 survey that occurred before green-up and under poor lighting conditions was unacceptable for determining a population estimate.

Under good flying conditions, our "normal" survey period in July and early August is the time least likely to give us an accurate population estimate. The fact that the summer average is much lower than other seasons is probably not nearly as significant as the range of 49 to 93%. It's interesting to keep in mind that flying with the poor conditions of scattered snow and clouds during winter is not as bad as July. I feel it is likely that the disparity in survey efficiency between July and other seasons is even greater than indicated by the data in Table 4. I picked the best possible conditions for the July surveys. I know biologists often are forced to fly when conditions are less than ideal and survey efficiency drops. Another factor, probably equally as important is related to visibility of neck bands. With antelope in small summer groups, I do not believe that I missed seeing and recording a neck band within a group of antelope that I counted. This was a definite problem with winter herds. Of 7 radios missed during winter surveys and searched for

at the end of the survey, 3 were located within herds I had previously counted. Because of this I feel the actual winter survey efficiency is higher than indicated in Table 4.

RECOMMENDATIONS

1. I recommend that as long as our antelope objectives are to harvest maximum sustainable yield, that we continue making aerial population estimates.

2. I recommend flying only with good light conditions, whatever the season of the year.

3. I recommend not flying during the hunting season which yielded estimates no better (or worse) than winter or spring.

4. I recommend phasing out summer surveys during our "normal" period of flying. Much more reliable population estimates are possible in winter and during spring green-up.

The change will obviously cause some problems, none of which seem insurmountable. Some of the more obvious problems are as follows.

1. July normally has more good flying days in Montana than any other month.

2. The priorities of an area biologist may not allow for rescheduling current winter or spring activities.

3. We will not get age and sex data during winter surveys. If this is a priority, a random sample during summer may prove sufficient. The spring green-up period allows for counting males, and with minor practice, separating yearling males (11 mo old) from mature males. This should indicate actual recruitment and is probably more useful than our current summer fawn counts.

4. Antelope distribution, particularly in winter may necessitate learning actual population boundaries before accurately setting hunting quotas.

5. Spring dispersal may complicate setting accurate hunting quotas.

LITERATURE CITED

Jorgensen, Henry E. 1979. Vegetation of the Yellow Water Triangle, Montana. U.S.D.I. Bur. Land Manage., and Montana Dept. Fish, Wildlife and Parks, Helena. 57 pp.

Pyrah, Duane B. 1987. American Pronghorn Antelope in the Yellow Water Triangle, Montana. U.S.D.I. Bur. Land Manage., and Montana Dept. Fish, Wildlife and Parks, Helena. 121 pp.

Appendix Table 1. Marked antelope records from the Yellow Water Triangle, H.D. 420, 1985-1989

Date of Capture	Ear Tag Number	Collar Color	Collar Symbol	Collar Number	Radio Frequency	Radio Serial No.	Radio Attachment	Age	Comments
1985 7/17	21731	Green	White circle	H0970	151.760	3565	Rivet to Richy	4P	
1985 7/17	21732	Green	Red stripe on telonic belt	H0984	151.360	14637	Belt riveted to Richy	4P	
1985 7/17	21723	Blue	Open black circle	H2527	151.700	5652	Rivet to Richy	4D	hunter kill 1986
1985 7/17	21722	Blue	Black stripe on tel.belt	H0919	151.481	12333	Belt riveted to Richy	4P	caught with 21721
				killed 8/87 while net gunning, radio and collar reused 8/87					
1985 7/17	21748	Blue	Black circle	H2535	151.570	10416	Rivet to Richy	2P	hunter kill 1985
				radio reused on deer in H.D. 410					
1985 7/17	?	Blue	Open red circle	H2515	151.341	3545	Rivet to Richy	4P	caught with 21774
1985 7/17	21726	Green	Black stripe on tel.belt	H0916	150.880	19147	Belt riveted to Richy	1P	hunter kill 1986
1985 7/17	21730	Blue	White circle	H0996	151.376	5662	Rivet to Richy	4P	caught with 21729
				seen 7/26, died shortly thereafter· lactic acid ? radio and collar reused on deer H.D.410					
1985 7/17	21702	Blue	White square	H2549	150.860	10123	Rivet to Richy	1P	caught with 21703
1985 7/17	21775	Blue	White triangle	H2516	151.241	3541	Rivet to Richy	3P	hunter kill 1986
				radio reused on deer in H.D. 410					
1985 7/17	21749	Blue	Open white square	H2588	151.320	10134	Rivet to Richy	2P	
1985 7/17	21724	Green	Red,W & G square on t.belt	H0918	151.061	12311?	Belt riveted to Richy	4P	caught with 21725
1985 7/17	21704	Blue	Open white circle	H0995	150.890	10124	Rivet to Richy	4P	a second 4P in net died last seen 10/22/86
1985 7/17	21799	Blue	Open red square	H2587	150.700	1407	Rivet to Richy	4P	caught with 21800
				hunter kill 1986					
1985 7/17	21728	Blue	Red triangle	H2568	151.862	3496	Rivet to Richy	4P	hunter kill 1987
1985 7/17	21727	Blue	Red square	H2565	151.260	10132	Rivet to Richy	4P	
1985 7/17	21750	Blue	Open white triangle	H2567	151.274	5513	Rivet to Richy	4P	dead Oct.1985 cause ?
1985 7/17	21800	Blue	Red stripe					3P	caught with 21799
1985 7/17	21725	Green	2 red stripes	H2512				1P	caught with 21724
1985 7/17	21703	Blue	Red switchbacks	H2504				4D	caught with 21702
1985 7/17	21729	Blue	Black switchbacks	H?556				3P	caught with 21730
1985 7/17	21774	Blue	Black cross stripes	H0929				4D	caught with 21774
1985 7/17	21721	Blue	Black stripe				hunter kill 1986	4D	caught with 21722
1985 7/18	21738	Green	Black cross stripes on belt	H0920	150.871	12353	Belt riveted to Richy	4P	dead 1/87 coyote kill ?
1985 7/18	21735	Green	Open white triangle	H2531	151.850	5657	Rivet to Richy	4P	hunter kill 1985
1985 7/18	21720	Blue	Black triangle	H2536	151.640	10151	Rivet to Richy	4P	hunter kill 1986
1985 7/18	21707	Blue	Open black square	H0969	151.825	5656	Rivet to Richy	4P	
1985 7/18	21798	Blue	Black square	H2528	151.660	10152	Rivet to Richy	?	dead 1/87 hunter loss ?
1985 7/18	21708	Blue	Red stripe on tel.belt	H0913	151.451	19150	Belt riveted to Richy	3P	caught with male fawn 21706
1985 7/18	21709	Green	All red telonics belt	H0983	151.160	12365	Belt riveted to Richy	2P	dead 2/87 coyote kill ?
1985 7/18	21710	Green	All white telonics belt hunter kill 1986	H0915	151.000	19148	Belt riveted to Richy	2P	caught with 21711

Appendix Table 1. continued

1985 7/18	21713	Green	Red triangle	H2532	151.875	5455	Rivet to Richy	4P	dead Oct.1985,coyote kill ?
				radio reused on deer in H.D. 410					
1985 7/18	21733	Green	Red cross stripes on belt	H0917	151.020	12359	Belt riveted to Richy	4P	
1985 7/18	21734	Blue	Red circle	H2566	150.750	8975	Rivet to Richy	2P	sick 7/26,died-lactic acid
?									
				radio and collar reused on deer in H.D. 410					
1985 7/18	21705	Blue	Open red triangle	H2550	150.960	10118	Rivet to Richy	2P	
1985 7/18	21777	Blue	Red railroad track					?	caught with 21776
1985 7/18	21776	Blue	White cross stripe					2P	caught with 21777
1985 7/18	21711	Blue	White stripe					4D	caught with 21710
1985 7/18	21737	Blue	2 red stripes					4D	second 2P died in net
1985 7/18	21706	male fawn caught with 21708 female							
1985 7/18	?	2 fawns released							
1986 3/24	21781	Green	Open white triangle	H2531	151.850	5657	Rivet to Richy	4P	caught with 21781
			this is a reused collar from 21735- dispersed north into H.D.481-hunter kill 1988						
1986 3/24	21794	Yellow	Red arrow		151.000	10125		4D	caught with 21785
							dispersed east into H.D. 530		
1986 3/24	none	Red	White squares	H2520				2P	
1986 3/24	none	Red	White triangles	H0932				1P	caught with H0965
1986 3/24	21785	Blue	Red cross stripes	H2503				4D	caught with 21794
1986 3/24	21782	Blue	White railroad track	H0914				4P	
1986 3/24	21795	Blue	White switchbacks	H2540				4P	second 4P died in net
1986 3/24	21796	Blue	White circles	H2519				3P	dead 9/86 coyote kill ?
1986 3/24	none	Green	White cross stripes	H0965				1P	caught with H0932
							found dead 10/87 not recent		
1986 3/24	21779	Green	White pluses	H2539				4P	
1986 3/24	21792	Black	White switchbacks	H0940				2P	
1986 3/24	21788	Orange	White switchbacks	H0939				4P	
1986 3/24	21786	Red	White stripe	H0925				4D	caught with 21781
					dispersed north into H.D. 481 by 7/86				
1986 3/24	21783	White	Red switchbacks	H0931				2P	
1986 3/24	21797	Red	2 white stripes	H0981				1P	
1986 3/24	21791	Yellow	Red circle	H0526				1P	
1987 8/18	21755	Green	White stripe	H0963				4D	
1987 8/18	21767	Blue	Open black circles	H0920				4D	
1987 8/18	21714	Yellow	2 black stripes	H0916				4D	
1987 8/18	21712	Blue	Yellow double switchbacks	H0983				2P	
1987 8/18	21766	Blue	Black stripe	H0930				4P	
1987 8/18	21759	Yellow	Black Y Y	H2510				4D	
1987 8/18	21743	Yellow	Red lazy triangles	H2537				4P	
1987 8/18	21757	Blue	Black stripe on tel.belt	H0919	151.481	12333		2P	reused radio
					radio found 1/88, probably discarded by a hunter				

All radios were by telonics
All neck band bases were of 4 inch wide Richy brand, rubber-like material
All antelope were captured with a hand held, four barreled, net gun fired from a helicopter

Appendix Table 2. Data from aerial antelope surveys in H D. 420 for testing the efficiency of Montana's aerial surveys.

Date	Survey Numbers: Yrl. Male	Ad. Male	Fem	Fawn	Total	Minus Duplicates	F/100 Fem.	M/100 Fem.	Percent of Markers Observed	Percent Duplicates	Estimate No.1	Preferred Estimate	weather	pilot
1985														
7/26	22	87	(383)	134	626	354	35	28	25-33 (76)	8-33 (35)	407	411		A
8/18	48	94	(369)	118	629	358	32	38	30-36 (83)	2-36 (6)	415	411		A
10/17	40	75	(486)		601	481			27-31 (87)	2-31 (6)	522	553	marginal	B
1986														
1/13					(1013)	898			23-28 (82)	4-28 (14)	1055	1055		A
4/1	61	96	(607)		764	557		26	40-45 (89)	4-45 (9)	619	619	ideal	A
5/1	77	98	(448)		623	446		39	33-41 (80)	1-41 (2)	546	546		B
7/8	40	80	(314)	148	582	310	47	38	30-41 (75)	1-41 (2)	403	430		B
7/16	40	48	(340)	157	585	308	46	26	19-38 (50)	6-38 (16)	515	430		A
7/25	31	48	(221)	120	420	213	54	36	20-37 (54)	1-37 (3)	388	430		A
8/5	56	49	(266)	131	502	266	49	39	18-37 (49)	0	543	430		A
10/22					(660)	632			29-32 (91)	3-32 (10)	653	680		B
12/1					(502)	502			21-27 (78)	0	644	680	terrible	B
12/24					(740)	708			24-25 (96)	2-25 (8)	712	680		A
1987														
1/23					(650)	599			22-24 (92)	3-24 (13)	619	680		A
3/25					(477)	477			16-24 (67)	0	712	680	terrible	A
4/6	65	60	(475)		600	446		26	18-25 (72)	5-25 (20)	565	565		A
7/15	73	58	(316)	147	594	316	47	41	12-24 (50)	0	632	430		A
7/27	47	61	(272)	134	514	272	49	40	15-24 (63)	1-24 (4)	432	430		A
8/4	67	52	(337)	124	580	337	37	35	19-24 (79)	0	427	430		A
8/28	71	62	(368)	155	656	365	42	36	26-31 (84)	1-31 (3)	423	430		A
1988														
1/18					(519)	496			15-23 (65)	1-23 (4)	746	625	poor	A
2/25					(575)	543			24-24 (100)	1-24 (4)	552	625		
4/15					(507)	507			20-25 (80)	0	634	625		B
7/16	40	49	(245)	102	436	429	42	36	14-24 (58)	1-24 (4)	392	450		A
7/20	50	43	(247)	117	457	457	47	38	13-24 (54)	0	456	450		A
7/28	48	50	(213)	119	430	430	56	46	10-25 (40)	0	532	450		A
8/5	62	57	(312)	131	562	562	42	38	16-24 (67)	0	468	450		B
1989														
4/12	91	73	(525)		689	689		31	17-?	0	-	525		A

A MONITORING PROGRAM FOR PRONGHORN ANTELOPE IN CHIHUAHUA STATE, MEXICO

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Abstract: I conducted a census of pronghorn antelope (*Antilocapra americana*) and established permanent habitat and population monitoring transects at Rancho La Gregoria in 1989. Pronghorn groups and individuals were identified using direct observation and mapping techniques. A 15 km pronghorn observation transect was established and a density index calculated . Six vegetation transects and photopoints were established on lowland, upland, and disturbed sites receiving high pronghorn use. Vegetation species composition, frequency, and aerial-view cover were recorded. Thirty-nine pronghorn individuals (absolute count) occurred on the 145 km^2 study area, having a density of 0.27 individuals per km^2. The low adult male:adult female ratio (0.41) was attributed to poaching of trophy males. The low juvenile:adult female ratio (0.44) was attributed to coyote predation (73% estimated 1989 juvenile mortality). Management recommendations include implementing coyote control, rancher and public education, law enforcement, and reintroduction programs. KEY WORDS: Pronghorn, Chihuahua

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Acknowledgments: Funding and equipment for this study were provided by Fundacion Chihuahuense de la Fauna A.C. (The Chihuahuan Wildlife Foundation), Aldama y Ocampo #430, Chihuahua, Chihuahua, Mexico 31000.

The pronghorn antelope is in danger of extirpation in Mexico (Trevino, 1978; Habib de Pena and Pena Neira, 1982). In 1978, Trevino reported that approximately 550 pronghorn remained in Chihuahua State - down from an estimated 500,000 at the time of Spanish exploration. Trevino suggests that the current population is so small and scattered that inbreeding may be a threat (personal communication).

Research about the Chihuahua pronghorn has been minimal. Trevino determined their number and distribution in 1978. Habib de Pena and Pena Neira conducted a food habits study in 1982. More research is necessary to determine why pronghorn numbers are decreasing.

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The objectives of this study were: 1) to conduct a census of a known population, 2) to evaluate reproductive success and recruitment, 3) to establish a direct observation transect for detecting changes in numbers of the known population, and 4) to establish permanent vegetation transects and photopoints for monitoring long term changes in the habitat.

STUDY AREA

El Rancho La Gregoria is located 128 km north of Chihuahua City, Mexico, adjacent to the Panamerican highway. La Gregoria, originally one ranch, now consists of two separate ranches: Terraceno to the north and El Palomino to the south (Figure 1). It is comprised of 14,500 ha. The topography grades from plains in the west, to rolling hills and rugged, low mountains in the east. The vegetation is a mixture of blue grama (Bouteloua gracilis) grassland and blue grama-mesquite (Prosopis juliflora) open shrubland.

The mean annual precipitation is 356 mm of which 70% occurs during the July through September rainy season. The mean annual temperature is 14.5 C. The 189-day growing season occurs from April through October. (Data taken from Habib de Pena and Pena Neira, 1982) Elevations range from 1,520 to 1,900 m above sea level.

METHODS

A complete census (absolute count) of La Gregoria pronghorn was conducted using the direct observation technique combined with the mapping method. Pronghorn groups and individuals were observed using a 32-power spotting scope. Their locations and descriptions were recorded each observation-day during August and September, 1989. All individuals were classed as either juveniles or adults. Sex was determined for each adult.

A 15 km direct observation transect was established for future censuses, to acquire a density index, and to help detect changes in pronghorn numbers over time (Figure 1).

Six permanent vegetation transects and photopoints were established in areas frequented by pronghorn (Figure 1). Two transects and photopoints were established on lowland sites, two on upland sites, and two on sites disturbed during the construction of powerlines. Plant species composition, frequency of occurrence and aerial-view cover of vegetation, litter, rock and bare ground were recorder within 0.125 m^2 quadrats along 30 m transects. Overall color photographs of the vegetation were taken from the zero end of each transect looking towards the 30 m end. Close-up photographs were taken at each 10 m point from a height of 1.5 m.

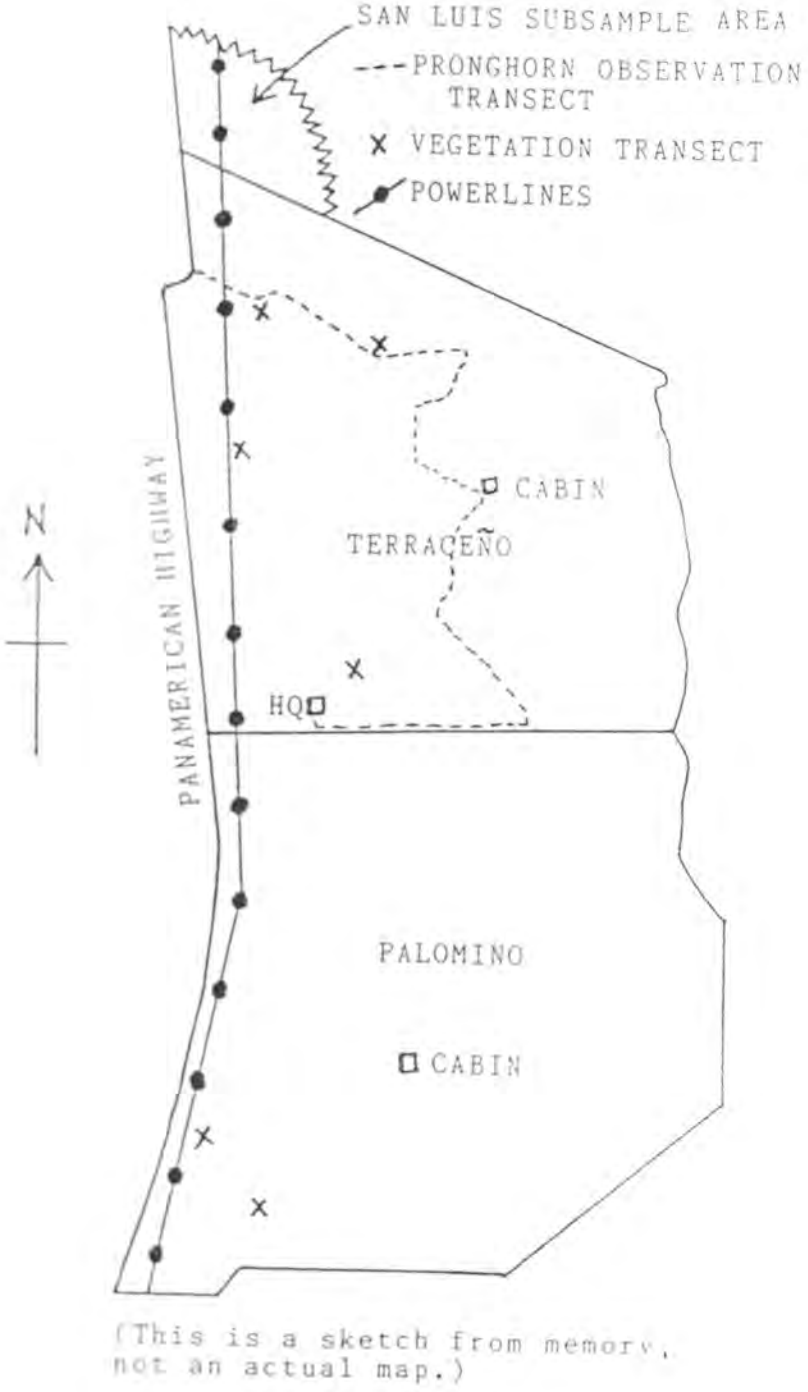

Figure 1. Study area, Rancho La Gregoria, Chihuahua, Mexico.

RESULTS

Pronghorn groups appeared to be relatively stable and territorial during the study. All resident pronghorn on the study area could be observed using a series of hills and vantage points. Although heat waves were a problem at times, all individuals could be sexed and aged using the spotting scope. A combination of group and individual recognition allowed for an absolute count to be taken.

A total of 11 adult males, 27 adult females, and 12 pronghorn juveniles were observed on El Palomino, Terraceno, and part of Rancho San Luis (Table 1). A total of 39 pronghorn occurred at La Gregoria. Eleven individuals observed at southwestern Rancho San Luis were added to the La Gregoria sample to yield more accurate sex and age-class ratios.

Table 1. Population composition for Rancho La Gregoria and southwestern Rancho San Luis[a] pronghorn, Chihuahua State, Mexico, 1989.

AREA	GROUP	ADULT MALE	ADULT FEMALE	JUVENILE	TOTAL
Terraceno	C	4			4
	D	1	6	2	9
	E	1	5	3	9
	Subtotal	6	11	5	22
Palomino	F	1	5	2	8
	G		1		1
	H	1	4	3	8
	Subtotal	2	10	5	17
San Luis	A	1	5	2	8
	B	2	1		3
	Subtotal	3	6	2	11
	TOTAL	11	27	12	50

[a]Rancho San Luis pronghorn were not censused; however, a subsample of the population was added to the La Gregoria sample to give more accurate sex and age-class ratios.

The adult male:adult female ratio was 0.41 (Table 2). The juvenile:adult female ratio was 0.44. The juvenile:adult ratio was 0.32. It is believed that the majority of adult females had twins. Assuming a 90% conception rate and an 85% twinning rate

for does, the 1989 juvenile mortality is estimated to have been 73%.

Table 2. Sex and age-class ratios for Rancho La Gregoria and SW Rancho San Luis pronghorn, Chihuahua State, Mexico, 1989.

Adult Male:Adult Female	0.41
Juvenile[1]:Adult Female	0.44
Juvenile:Adult	0.32

[1]73% estimated 1989 juvenile mortality.

The pronghorn density for Rancho La Gregoria was 0.27 individuals per km^2. The 1989 density index calculated for the pronghorn observation transect was 1.4 individuals per km, with a mean of 20.7 individuals observed each time the 15 km transect was sampled.

Vegetation on most sites appeared to be in low or mid seral states. Pronghorn feed was abundant. The ocularly-estimated aerial-view cover of vegetation averaged 26.1, 16.8, and 24.4% for lowland, upland, and disturbed sites, respectively (Table 3). Litter cover averaged 3.3, 1.9, and 2.9% on lowland, upland, and disturbed sites, respectively. Forty-two plant species were encountered on the vegetation transects with a mean of 17.2 species per transect. More forb species; however, graminoids appeared to account for more of the total aboveground biomass than forbs or shrubs.

Table 3. Aerial-view cover summary from permanent transects, Rancho La Gregoria, Chihuahua State, Mexico, 1989.

	AERIAL-VIEW COVER (%)		
Site:	Lowland	Upland	Disturbed
Vegetation[1]	26.1	18.6	24.4
Litter	3.3	1.9	2.9
Bare Ground & Rock	70.6	79.5	72.7

[1]42 plant species encountered: a mean of 17 species per transect.

DISCUSSION

Pronghorn females were observed fawning in late July and early August during the onset of the rainy season in the rugged hills and low mountains in the eastern part of the study area,

presumably to avoid predators. Fawning at this time would assure adequate nutrition for the lactating does and their kids. After fawning, the does led their kids to the drainage bottoms in the western part of the study area. The high juvenile mortality, about 73%, was probably due mostly to coyote predation. During the study coyotes were sited 13 times in groups ranging from 1 to 4 animals. One el Palomino doe was observed chasing a coyote away from its kid. The coyote had been able to sneak to within 5 m of the kid using tall grass for cover.

The Low adult male:adult female ratio (0.41) probably can be attributed to poaching of trophy males. The Chihuahua pronghorn currently are protected by Mexican federal and state law. However, the cowboys and one ranch owner believe that poaching of the pronghorn may be occurring from public roads and powerline right-of-way. A cowboy reported finding one dead adult male near the powerlines and highway at El Palomino that may have died from a bullet-inflicted injury. I have heard reports of pronghorn poached from roads, aircraft, and killed at night with the aid of spotlights. One Chihuahua City man reportedly operates a guiding service for pronghorn hunters. The cowboys believe that the pronghorn move high into the eastern hills or possibly onto other ranches during the winter months. Therefore, it is possible that illegal killing of pronghorn is occurring on breeding/wintering areas away from the study area. The level of poaching on the female segment of the population is unknown; therefore, the low adult male:adult female ratio may not be an accurate indication of the overall level of poaching that is occurring.

Plant species frequency of occurrence will have to be resampled in 3 to 5 years between September 1 and 15 to help determine vegetation ecological trend. Photopoints should be resampled at the same time for comparison purposes. The direct observation transect should be sampled 3 times annually between September 1 and 15 to detect changes in the density index. A 32-power spotting scope should be used during a 4-hour observation period.

The study area appears capable of supporting a base population (total number of adults) in excess of 200 pronghorn without adversely affecting the livestock forage resource. The majority of ecological sites are in a low to mid seral state with an abundance of forbs and small shrubs including Artemisia spp., Hoffmanseggia spp., and Euphorbia spp. Habib de Pena and Pena Neira (1982) reported that La Gregoria pronghorn consumed mainly forbs and shrubs, with grasses comprising only about 4% of their annual diet. Therefore, it would be advantageous for ranchers in the area to manage for pronghorn and cattle, both of which have a high economic value, on the same land. The dietary overlap between the two species would be less than 10%.

MANAGEMENT RECOMMENDATIONS

The following recommendations were given to Mexican wildlife officials and the owners of Terraceno and El Palomino as guidelines for increasing the pronghorn numbers in the La Gregoria area:

1) Practice coyote control including night calling, snaring, trapping, and cyanide gunning in late spring and early summer in and near pronghorn fawning grounds.
2) Determine where and how La Gregoria pronghorn are being poached. Control illegal hunting on and off of the Ranch. Stiffen the penalties against poachers. Prosecute offenders.
3) Begin an educational program for ranchers and the public emphasizing the importance of protecting the pronghorn.
4) Maintain the vegetation in a mid seral state providing an abundance of forbs and low shrubs for pronghorn feed, yet at the same time decreasing coyote densities by decreasing the overall prey base.
5) Implement pronghorn habitat improvements such as:
   a. Control mesquite with 2,4,5-T, diesel oil, or kerosene in areas where it is too dense.
   b. Clean out and deepen major water holes to provide a more reliable, widespread, and permanent water supply.
   c. Supply mineral salt in areas of heavy pronghorn concentration during winter and spring to improve their nutritional status.
   d. Raise the bottom strand of fences to a height of 45 cm in areas where pronghorn cross or show an interest in crossing.
6) Consider importing several pronghorn males for release at La Gregoria to increase the population's genetic diversity and avoid inbreeding.
7) With the aid of cooperating ranchers, attempt pronghorn reintroductions on ranges they formerly inhabited.

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EVALUATION, ISSUES, AND CHALLENGES OF THE WILDLIFE RANCHING PROGRAM IN COLORADO

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Abstract: I evaluated a cooperative private lands wildlife management program called "Wildlife Ranching" for a 3-year period (1986-88) on 10 ranches. Nearly 800,000 acres of private land were opened to public hunting. A total of 2,634 licenses for 6 species was allocated to private hunters (55.2%) and public hunters (44.8%). Numbers of licenses allocated by species included: deer (*Odocoileus hemionus*, *O. virginianus*) (1,046), elk (*Cervus elaphus*) (938), and pronghorn (*Antilocapra americana*) (609), black bear (*Ursus americanus*) (7), and turkey (*Meleagris gallopavo*) (34). Nine hundred and twenty animals were harvested by 1,126 active private hunters (82% success), while 969 active public hunters took 737 animals (76% success). Private landowners that participated in the experiment were generally supportive of the program, but public acceptance of the program was mixed.

Approximately two-thirds of Colorado's 103,480 mi^2 of land and water area is privately owned, and these areas play a key role in management of the State's wildlife resources. They provide valuable wildlife habitats, such as big game winter ranges, but also contribute important habitats on a year-round basis.

Despite their importance to public wildlife resources, private lands complicate the ability of the Division of Wildlife (DOW) to adequately manage many wildlife populations. Absence of DOW control over habitat protection and public access on these lands frustrates the agency in efforts to meet its statewide management objectives. This situation has encouraged the DOW to investigate new and innovative ways to address wildlife management on private lands. Certain realities face the DOW that make this essential, including (1) increase public demand for wildlife-oriented recreation, (2) a declining wildlife habitat base, (3) difficulty in effectively implementing management plans by species, herds, etc., (4) continued high costs associated with game damage, and (5) less than desirable DOW-landowner-sportsman relationships.

Traditionally, private landowners have viewed wildlife as a liability rather than an asset; consequently, protection and management of wildlife habitats on these lands have not been a priority compared to other land uses. Economic incentives to make wildlife management a priority have largely been lacking.

Yet, many private landowners seek alternative or supplemental sources of income from their lands because of an uncertain agriculture economy.

The future of wildlife management in Colorado demands that both the public and the DOW recognize private land contributions to wildlife habitats of public resources. Opportunities for various types of economic incentives or compensations are 1 form of recognition. Implementation of a program offering landowner incentives while providing the DOW increased flexibility in managing wildlife on private lands potentially benefits both private and public interests, as will as the resource. Ideally, any program designed to manage wildlife on private land involves a cooperative venture between the DOW and landowner. The long-term success of such a program is determined by its ability to:

1. Preserve and protect wildlife habitat.
2. Improve and develop wildlife habitat.
3. Provide more public access and recreational opportunity.
4. More effectively implement species plans by management units.
5. Decrease game damage costs.
6. Improve DOW-landowner-sportsman relationships.
7. Minimize costs to the DOW.
8. Gain public acceptance.

In 1985, the Wildlife Commission asked the DOW to investigate the potential for a cooperative private lands wildlife management program based on a concept in California known as "Range for Wildlife." The DOW studied the concept and proposed a program that it felt could satisfy the 8 long-term objectives listed above. In 1986, the Wildlife Commission directed the DOW to conduct a 3-year pilot program to test the new concept on several ranches.

The objective of the 3-year experimental program was:

> **To evaluate the concept of "Wildlife Ranching" for cooperatively managing wildlife on private lands during the period 1986-88.**

"Wildlife Ranching" is a program that encourages private landowners to actively participate in the conservation, utilization, and propagation of wildlife on their lands on a cooperative basis with the DOW, i.e. it offers the opportunity for private landowners to become more involved in the management of the State's wildlife resource without the State relinquishing any of its authority over the resource. The program provides the economic incentive for landowners to practice wildlife management on private lands, including habitat protection and improvement, and population manipulation through harvest by both private and public hunters.

By law, Colorado's wildlife belongs to the people of the State, with full authority for management of that wildlife vested in the Wildlife Commission. Concern has been expressed that the Wildlife Ranching Program would result in the undermining of this statutory charge, and that Commission authority would be relinquished to the private landowners. Under Wildlife Ranching, or any other program involving management of State-owned wildlife on private lands, the Commission intends to retain complete authority. The Wildlife Ranching program includes only wild, free-ranging animals, thus private landowners cannot erect animal-proof fencing that prevents free movement of these animals on and off their property. In addition, all wildlife regulatory authority empowered to the Wildlife Commission by Colorado Statute applies under the program, including final approval of season dates, license numbers, etc.

METHODS

Selection of Test Ranches

The experimental Wildlife Ranching Program included 2 ranches in 1986, 7 in 1987, and 10 in 1988. Ranches selected were those that met the following requirements of the program:

1. Minimum size land area of 5,000 acres.
2. Commitment to the program by the landowner through the signing of a cooperative agreement with the DOW for a 3-year period.
3. Preparation of a wildlife management plan by the landowner for the ranch.
4. Agreement by the landowner to allow public hunting.

A cooperative agreement was not fully executed until the DOW received and approved a wildlife management plan. Plan preparation followed a standardized format including pertinent background information and proposed habitat, census and harvest objectives, and strategies. The plan, along with the legal description of the ranch, were required attachments to the cooperative agreement. The cooperative agreement stated that any and all costs associated with habitat development or improvement projects identified in the management plan were to be borne totally by the landowner.

Season dates were not restricted to regular, statewide seasons. Flexibility was allowed in length and timing of both private and public seasons. Season dates could be split and each species under the program could have different season dates.

Hunting Season Dates and Numbers and Distribution of Licenses

Local DOW representatives and ranch personnel met annually to develop recommended season dates and numbers and distribution of hunting licenses to be allocated to a specific ranch.

The distribution of antlered and antlerless big game (deer, elk, pronghorn) licenses between private and public hunters was determined by the ranch through selection of 1 of 4 trial options (Table 1). The only constraint the Wildlife Commission placed on developing these trial options was that some antlered licenses be allocated to public hunters. A standardized formula was not developed for other species, rather DOW personnel and the ranch negotiated a distribution of licenses between private and public hunters.

Table 1. Options available for distribution of antlered and antlerless licenses between private and public hunters.

Option	Landowner's share of licenses (% of total)		Public's share of licenses (% of total)	
	Antlered	Antlerless	Antlered	Antlerless
1	95	0	5	100
2	90	25	10	75
3	85	50	15	50
4	80	>50	20	<50

The trial options presented different proportions of antlered and antlerless licenses for distribution between private and public hunters based on a sliding scale. A different option could be selected for each species. The standard DOW regulations-setting process was followed in submitting season date and license number recommendations to the Wildlife Commission for approval.

Issuance of Licenses

The private share of licenses was offered directly to individuals of the ranches choice without going through a drawing. The public's share of licenses for each ranch under the program was issued through the DOW's normal limited license drawing process.

Each ranch was provided names and addresses of all public hunters successful in drawing a license for their ranch. A map and list of hunting rules for each ranch was prepared in cooperation with ranch personnel and sent to each public hunter prior to the season, along with a cover letter explaining the

program. Ranches under the program had the option of charging the public a limited access fee not to exceed $25 for each license.

Evaluation Process

Each ranch was provided standard forms and requested to maintain and submit annual records of both private and public hunting activities on their ranch. Local DOW personnel were asked to assist in supplying this information. Specifically, the following information was requested by species of animal hunted:

1. Number of licenses issued (private hunters only).
2. Number of hunters that actually hunted.
3. Number of antlered and antlerless animals harvested.
4. Other information concerning hunting conditions, problems, recommendations, etc.

Following the end of the 3-year experiment, participation ranchers and many DOW personnel were contacted and asked for their observations and recommendations relative to the program to aid in evaluation of the overall program. The Wildlife Commission held 2 public meetings on the Wildlife Ranching Program in 1988 to explain the program and to solicit public input. In addition, 1 ranch (Forbes Trinchera) conducted its own public hunter opinion survey during the 1987 and 1988 seasons by distributing questionnaires to hunters as they entered the property.

RESULTS AND DISCUSSION

Participating Ranches

Seven of the 10 ranches under the experimental Wildlife Ranching Program occur in the Southeast Region of the state, 2 in the Southwest Region, and 1 in the Northwest Region (Fig. 1). They range in size from about 9,400 acres to 300,000 acres, with a total acreage of 799,130 (Table 2). Only Forbes Trinchera and Taylor ranches participated in the program for the entire 3-year experiment, while 3 ranches (River Canyon, Tercio, and Urie) participated only 1 year (Table 2).

Species Under the Program

Six species of wildlife were managed under the experimental program--mule deer, white-tailed deer, elk, pronghorn, black bear, and turkey. Deer were under 8 of the 10 ranch programs, while 6 ranches were managed for pronghorn, 4 for elk, 2 for turkey, and only 1 for bear (Table 3). Two ranches (Drawdel and Urie) managed for a single species (pronghorn).

Table 2. Participating ranches under the experimental Wildlife Ranching Program, 1986-88.

Ranch	Approximate acreage	Years of participation 1986	1987	1988
Forbes Trinchera	170,000	X	X	X
Taylor	77,000	X	X	X
Bijou Springs	18,900		X	X
Drawdel	300,000		X	X
Geesen	10,600		X	X
Hill	32,370		X	X
River Bend	15,400		X	X
River Canyon	150,000			X
Tercio	9,400			X
Urie	16,000			X
Total	799,130	2	7	10

Table 3. Wildlife species under experimental Wildlife Ranching Program by ranch, 1986-88.

Ranch	Species under program Deer	Elk	Pronghorn	Bear	Turkey
Forbes Trinchera	X	X			
Taylor	X	X			
Bijou Springs	X		X		
Drawdel			X		
Geesen	X		X		
Hill		X	X		X
X					
River Bend	X		X		
River Canyon	X		X		
Tercio	X	X			X
Urie				X	
Total	8	4	6	1	2

Season Dates and Lengths

The timing and length of hunting season varied by ranch, species, year, and between private and public seasons. Most private deer seasons started in September or October, while all private elk seasons began in early to mid-September. Private pronghorn seasons usually started in mid-September. After the first year, nearly all ranches selected private season dates that

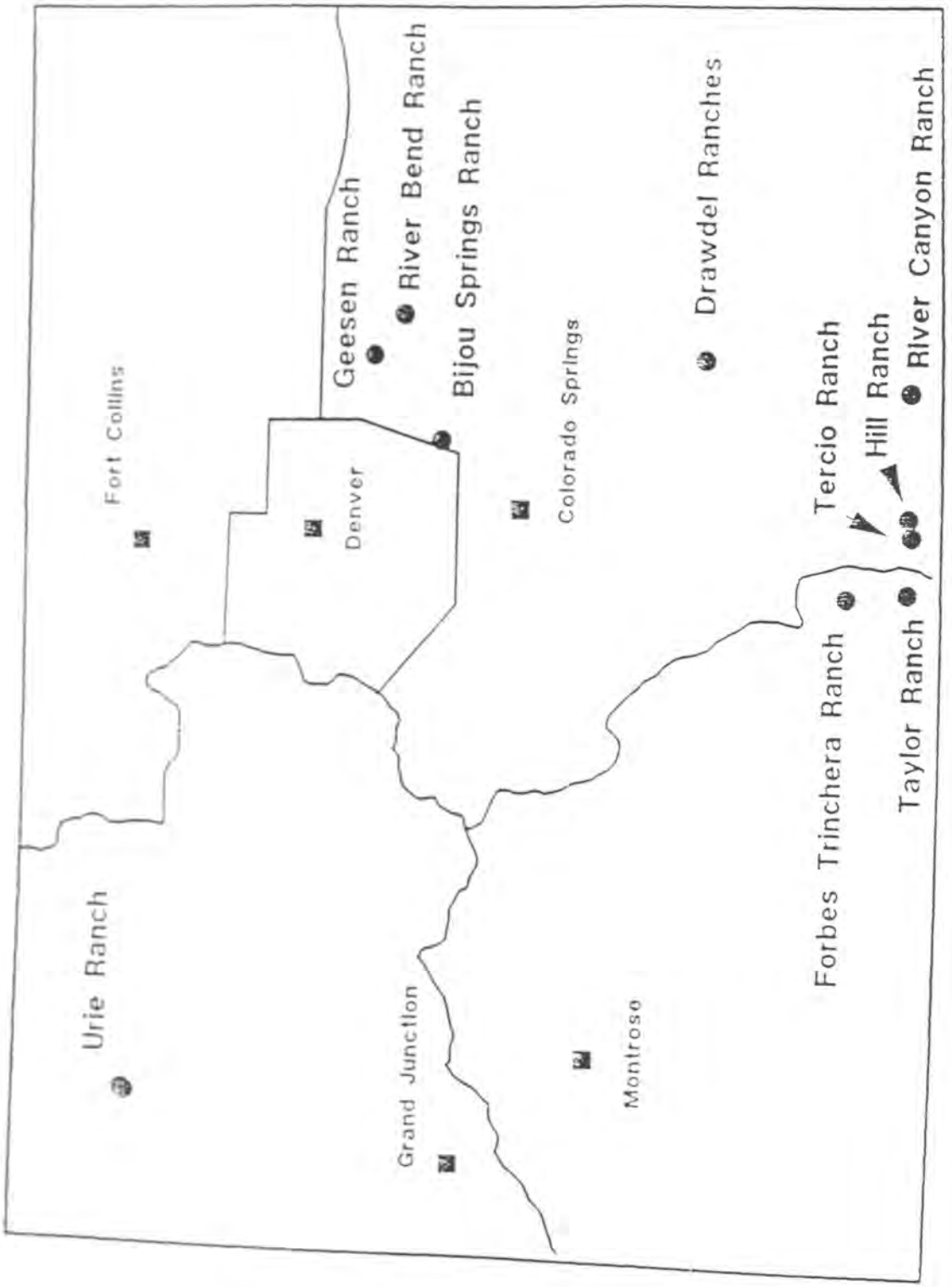

Figure 1. Location of participating ranches under the experimental Wildlife Ranching Program, 1986-1988.

coincided with at least a portion of the rut for each species. Split seasons for each species were common for private hunts.

Public deer and elk seasons did not start before mid-October, and most not until mid- to late November or December. Public pronghorn seasons started in late September or early October. None of the public elk seasons occurred during the rut, whereas many of the public deer seasons were within the period of rut. Public seasons were not commonly split for a given species.

Average deer, elk, and pronghorn season lengths for private hunts on the 10 ranches were 58.7, 68, and 33.3 days, respectively (Table 4). In contrast, public hunts for these species averaged 8.1, 5.6, and 6.7 days, respectively. Season lengths varied among ranches for each species for private hunts, but were consistent for public hunts.

A season length of 76 days was established in 1988 for both private and public bear hunts on the 1 ranch (Hill) managed for bear. Also in 1988, the private turkey seasons on Hill and Tercio ranches were 46 and 127 days, respectively, with a public hunt of only 8 days on each ranch.

Table 4. Comparison of season lengths between private and public hunting seasons, 1986-88.

Species	Private		Public	
	Ave. season length (days)	Range (days)	Ave. season length (days)	Range (days)
Deer	58.7	12-91	8.1	5-19
Elk	68.0	54-91	5.6	5- 6
Pronghorn	33.3	4-76	6.7	4- 7
Bear	76.0	76	76.0	76
Turkey	86.5	46-127	8.0	8

Number and Allocation of Licenses

Ranches selected Option 1 (Table 1) most often for distributing antlered and antlerless licenses between private and public hunters for deer and elk (Table 5). Options 3 and 4 were most popular for distributing pronghorn licenses. Only 1 ranch (Taylor) selected an option that gave private hunters a share of the antlerless elk licenses. In contrast, most ranches managed for deer and pronghorn selected options that made antlerless licenses available to private hunters.

Antlerless deer licenses were not offered to either private or public hunters on 2 of the 8 ranches managed for deer. This option was not covered under the schedule of options developed for the 3-year experiment (Table 1); however, in this situation

the public received 5% of the total antlered licenses, but not less than 1 license.

Table 5. Options selected for distribution of antlered and antlerless licenses between private and public hunters.

Species and year		No. of ranches selecting option			
		Option			
		1	2	3	4
Deer	1986[a]	1	0	0	0
	1987[b]	1	1	1	1
	1988[b]	3	0	2	1
	Subtotal	5	1	3	2
Elk					
	1986	1	1	0	0
	1987	2	1	0	0
	1988	3	1	0	0
	Subtotal	6	3	0	0
Pronghorn					
	1987	0	0	2	2
	1988	2	1	1	2
	Subtotal	2	1	3	4
Total		13	5	6	6

[a] No antlerless deer licenses were allocated for 1 ranch.
[b] No antlerless deer licenses were allocated for 2 ranches.

A total of 2,634 licenses was allocated to the 10 ranches for private and public hunters during the 3-year experiment (Table 6). Included were 1,046 deer, 938 elk, 609 pronghorn, 7 bear, and 34 turkey licenses. The 2,593 deer, elk, and pronghorn licenses were for 1,406 antlered and 1,187 antlerless animals.

Public hunters were allocated 44.8%, or 1,181 of the 2,634 licenses (Table 6). Percentage of total elk licenses going to the public was somewhat lower (42%) than that for either deer (49%) or pronghorn (45%).

Nearly 88% of the total antlerless licenses, but less than 10% of the total antlered licenses, were allocated to public hunters (Table 6). This reflected the popularity of Option 1 (Table 1) among ranches; it being the option with the highest percentage of antlerless licenses and the lowest percentage of antlered licenses available to the public. The tendency for ranches to select Options 3 and 4 for pronghorn resulted in 17%

Table 6. Number of licenses allocated by species and the percentage allocated to the public, 1986-88.

Species	No. of licenses allocated			% to public		
	Antlered	Antlerless	Total	Antlered	Antlerless	Total
Deer	536[a]	510	1.046	8.0	91.6	48.8
Elk	563	375	938	6.2	94.7	41.6
Pronghorn	307[b]	302	609	17.3	73.2	45.0
Bear	---	---	7	----	----	14.3
Turkey	---	---	34	----	----	17.6
Total	1,406	1,187	2,634	9.3	87.9	44.8

[a] Includes 2 either sex licenses.
[b] Includes 95 either sex licenses.

of the buck licenses going to the public, as opposed to only 8 and 6% of the antlered deer and elk licenses, respectively, allocated to public hunters.

Percentage of total licenses allocated to the public was not consistent among the 10 ranches for the 3-years combined (Table 7). The public received over 50% of the total licenses allocated to each of 4 ranches (Forbes Trinchera, Bijou Springs, Drawdel, and Urie). A much lower percentage (25-35%) was allocated to each of 4 other ranches. These differences reflected factors inherent in the schedule of options for deer, elk, and pronghorn, as well as the absence of a standardized method to equitably distribute bear and turkey licenses between private and public hunters.

Number of antlerless licenses in relation to the number of antlered licenses was the biggest factor that determined the percentage of total deer, elk, of pronghorn licenses allocated to the public for a given ranch. For example, the 2 extremes experienced in 1988 compared Forbes Trinchera Ranch with Taylor Ranch and Hill Ranch. A total of 270 deer licenses (120 antlered and 150 antlerless) was allocated to the Forbes Trinchera Ranch, of which 156 (6 antlered and 150 antlerless), or 58%, went to the public. In contrast, no antlerless deer licenses were allocated to either the Taylor Ranch or Hill Ranch, resulting in only 20% of the total deer licenses for Taylor Ranch (5 of 25 antlered) and 4% of those for Hill Ranch (1 of 26 antlered) going to the public. This points out the failure of the schedule of options to address the possibility that no antlerless licenses would be allocated for a given species.

Table 7. Total number of licenses allocated and the percentage of total licenses allocated to the public by ranch, 1986-88.

Ranch	Total no. of licenses allocated	% to public
Forbes Trinchera	1,291	51.0
Taylor	290	31.0
Bijou Springs	52	51.9
Drawdel	215	51.2
Geesen	250	40.0
Hill	146	24.6
River Bend	94	42.6
River Canyon	77	35.1
Tercio	94	28.7
Urie	125	52.0
Total	2,634	44.8

Only 14% of the total bear and turkey licenses for Hill Ranch, and 18% of the total turkey licenses for Tercio Ranch, were allocated to the public. This inequitable distribution of licenses contributed to the low percentage of total licenses allocated to the public for all species combined (Table 7).

Licenses Issued

None of the 10 ranches issued all of the licenses allocated for private use every year of the experimental program. Overall, landowners issued 81-87% of their antlered deer, elk, and pronghorn licenses (Table 8). The percentages were even lower for antlerless licenses, especially elk (15%) and either-sex pronghorn (42%), and turkey (14%) licenses. The DOW did not specify that ranches had to issue all of their licenses.

Interest in the public licenses for the 10 ranches was high, especially the antlered licenses (Table 8). Number of applicants for antlered licenses of each species exceeded number available on every ranch during each year. Preference points were required in most cases to draw these public licenses, with some successful applicants using as many as 2 points for buck deer, up to 5 for bull elk, and up to 7 for buck antelope. The number of preference points required to successfully draw a license generally increased from 1986 to 1988, indicating a greater competition for these licenses as the experiment progressed.

Table 8. Percent of allocated licenses actually issued to private and public hunters by species, 1986-88.

Species	Percent of allocated licenses issued		
	Antlered	Antlerless	Either sex
Private Hunters			
Deer	87.2	76.7	-----
Elk	86.7	15.0	-----
Pronghorn	81.1	70.4	42.1
Bear	----	----	100.0
Turkey	----	----	14.3
Public Hunters			
Deer	100.0	91.6	100.0
Elk	100.0	96.9	-----
Pronghorn	100.0	53.8	-----
Bear	-----	-----	100.0
Turkey	-----	-----	100.0

Antlerless licenses available to the public were often under subscribed on many of the ranches, particularly for deer and pronghorn. Two ranches, Forbes Trinchera and Taylor, were the only ones for which all public licenses were issued during each year of participation in the program. For all years combined, 92, 97, and 54% of the antlerless deer, elk, and pronghorn licenses, respectively, were issued to public hunters for the 10 ranches (Table 8). Applicants sometimes used 2-4 preference points to successfully draw an antlerless elk or pronghorn license, while 1 point was the most used to draw an antlerless deer license.

Harvest and Hunter Success

Nearly 2,100 private and public hunters harvested 1,657 deer, elk, pronghorn, bear, and turkey on the 10 ranches during the 3-year experimental program (Table 9). Of these totals 1,126 private hunters took 920 animals (82% success) and 969 public hunters harvested 737 animals (76% success).

Deer. Private hunters harvested 357 antlered and 27 antlerless deer on the 8 ranches managed for deer, with success rates of 85% and 81%, respectively (Table 9). Nearly 85% of the antlered harvest (300) occurred on Forbes Trinchera Ranch where the success rate was 95%. This caused the average success rate for all 8 ranches combined to be high (85%) despite substantially lower harvests and success rates on each of the other 7 ranches. Without Forbes Trinchera Ranch, average success rate was only about 53%.

Table 9. Hunter participation, harvest, and success rate on 10 ranches, 1986-88.

Species & type of hunter	Antlered			Antlerless		
	No. of active hunters	Harvest	Hunter success (%)	No. of active hunters	Harvest	Hunter success (%)
Deer						
Private	422	357	84.6	33	27	81.2
Public	39	22	56.4	394	374	94.9
Subtotal	461	379	82.2	427	401	93.9
Elk						
Private	447	355	79.4	2	0	0
Public	34	15	44.1	334	197	59.0
Subtotal	481	370	76.9	336	197	58.6
Pronghorn						
Private	154	129	83.8	58	44	75.9
Public	51	43	84.3	111	85	76.6
Subtotal	205	172	83.9	169	129	76.3
Total						
Private	1,023	841	82.2	93	71	76.3
Public	124	80	64.5	839	656	78.2
Total	1,147	921	80.3	932	727	78.0

Public hunters took 22 antlered and 394 antlerless deer, with success rates of 56 and 95%, respectively (Table 9). Again, Forbes Trinchera Ranch contributed most of this harvest (91%), with a success rate of 97%. Success rate was over 50% on each of the other 5 ranches with antlerless licenses.

Success rates during the 1986 and 1987 statewide rifle seasons averaged about 25% for antlered and 68% for antlerless deer (DOW, unpubl. data). These figures are substantially below those achieved by both private and public hunters under the experimental Wildlife Ranching Program.

Elk. Harvest of antlered elk by private hunters on 4 ranches totaled 355 animals, with an average success rate of 79% (Table 9). Forbes Trinchera Ranch harvested 248 of this total at a success rate of 92%. Success rates on the other 3 ranches were 54-82%. These high success rates largely reflect hunting bulls during the rut.

Public hunters harvested 15 antlered elk (44% success) and 197 antlerless elk (59% success) on the 4 ranches (Table 9). All except 22 of the 197 antlerless elk were taken on Forbes Trinchera Ranch (72% success).

Success rates under the Wildlife Ranching Program were higher than those experienced during recent statewide, rifle elk seasons. For example, in 1986 and 1987 statewide success was only 10-15% for antlered and 35-40% for antlerless elk (DOW, unpubl. data).

Pronghorn. Private hunters harvested 129 pronghorn bucks and 44 does on 6 ranches, with average success rates of 84 and 76%, respectively (Table 9). Public hunters took fewer animals, 43 bucks and 85 does, but average success rates were nearly identical to those for private hunters. Private hunters were more successful than public hunters on only 2 ranches. Statewide success on all pronghorn during rifle seasons was 71% in 1986 and 76% in 1987, somewhat lower than that obtained under the Wildlife Ranching experiment (DOW, unpubl. data).

Bear and Turkey. Six private hunters harvested 5 bears on Hill Ranch for a success rate of 83%. The holder of the single public license did not hunt. A total of 3 turkeys was taken by 4 private hunters on Hill and Tercio ranches, while 5 public hunters were not successful.

Acceptance of Program

Ranches were generally pleased with results of the experiment. They did not have any major problems with either private or public hunter, or with the DOW. All participating ranches supported continuation of the Wildlife Ranching Program on an ongoing basis as conducted during the experimental period.

Public acceptance of the program was not unanimous. Some members of the public disagreed with the concept and felt the program subsidized private landowners and allowed commercialization of a public resource. Others accepted the concept but were dissatisfied with the program in the experimental form. Yet another segment of the public supported the program as conducted during the experiment. Support for the program appeared to be greatest among public hunters who actually participated. The survey of public hunters conducted by Forbes Trinchera Ranch in 1987 and 1988 showed overwhelming support for continuation of the program. Feedback from public hunters on the other ranches, although not formalized, was also mostly positive.

The public meeting held in Pueblo in 1988 to explain the program was largely negative and somewhat hostile. In contrast, the public meeting in Fort Garland reflected strong support for the program on Forbes Trinchera Ranch by San Luis Valley residents. The people here expressed desire to see the program continue because of additional hunting opportunity and business generated by the seasons.

Comments from DOW personnel were mostly supportive of the program, with some reservations and concern, Major issues raised by the public and some DOW personnel as listed and discussed below deal primarily with the question of equity of benefits under the program between the ranches and the public.

1. **The minimum acreage requirement for ranch participation is too low.**

In terms of public benefits, the program appears to work well on larger ranches where there is likely to be substantial numbers of licenses allocated to the public. Smaller ranches, on the other hand, may have relatively few licenses, thereby offering minimal public benefits. For example, the allocation of only 1 antlered and a handful of antlerless licenses to the public for a ranch merely complicates regulations and requires administrative effort that outweighs benefits.

The minimum acreage could be increase, but other factors must be considered in deciding whether or not to accept a ranch in the program. Important factors include the number of species to be managed and the availability of both antlered and antlerless licenses, each of which affects numbers of public licenses. For example, a 10,000-acre ranch managed for 2 or more species, including harvest of both sexes, may have more total public licenses than a 25,000-acre ranch managed for only 1 species and no antlerless harvest. Additional factors, such as habitat protection, game damage, and other management problems, should also be considered.

2. **The percentage of antlered licenses and total licenses allocated to the public is currently inequitable.**

This was probably the most common criticism of the experimental program. Under Option 1 of the trial schedule of options (Table 1), private hunters received 95% of the antlered licenses, while the public got only 5% of the antlered but 100% of the antlerless licenses. Overall, however, public hunters received nearly 1)% of the antlered licenses for all ranches and species combined (Table 6). This occurred because some landowners selected Options 2-4 which allocated a higher percentage of antlered licenses to the public. The program would be more acceptable to the public if they received a higher percentage of the antlered licenses. There is obviously a point in the percentage distribution of antlered licenses between private and public hunters at which the incentive for private landowners to participate in the program would no longer exist.

There was considerable variation among the 10 ranches in the percent of total licenses the public received by species and all species combined. Again, this was the result of factors inherent in the test schedule of options and the absence of a standardized method for distributing licenses for some species. Of the total number of licenses allocated to a ranch, a minimum percentage received by the public could be established to assure some consistency among ranches and to proved optimum public benefits.

This maximum percentage, in order to retain some flexibility, meed not apply to individual species, but simply to the total license allocation for a ranch.

It is questionable whether or not a species should be included in the program for a ranch if management for that species does not include a female harvest strategy. Modern management of healthy big game populations includes at least some female harvest. However, in negotiating an agreement with a ranch it may be decided that no females will be harvested, but that males can be harvested without negatively impacting the population. In this event, a more equitable distribution of those male licenses between private and public hunters seems appropriate.

3. **private hunters receive much longer seasons with better timing than public hunters.**

Flexibility in length and timing of hunting seasons is a primary incentive for a ranch to participate in the program. This allows the landowner to book private hunts over an extended period to accommodate more hunters, thereby reducing demands on ranch personnel and maintaining quality hunting. Long seasons also permit the selection of dates that include the period of rut for deer and elk when antlered animals are more vulnerable and the quality of the hunting experience is high. Individual private hunters, however, do not normally hunt more than 5-7 days, since most are non-residents and simply cannot spend more time. Private hunters receive a limited number of license, thus regardless of season length harvest is restricted to the number of licenses issued.

Hunting antlered animals is a more selective process than hunting antlerless animals. Therefore, since private hunters have most of the antlered licenses, additional time to make their selections is important. On the other hand, harvest of antlerless animals by public hunters usually takes only 1-2 days, so longer public seasons are largely unnecessary. However, for public hunters with antlered licenses, additional hunting time would be desirable.

4. **Charging public hunters an access fee is detrimental to the program.**

One ranch in 1987 and 2 ranches in 1988 elected to charge public hunters an access fee. Critics of this activity argue that in most cases private landowners already derive substantial revenues from their private hunters and that the $25 public fee is an over commercialization of the program. The relatively small amount of additional income from the public fee may not be worth the negative image it creates for the program.

The possibility that an access fee would be charged appeared to decrease public interest in available antlerless licenses during the experiment. All public licenses must be issued in order to increase DOW and public support of the program and to maximize benefits.

Program Costs

The DOW conducted the 3-year experimental program with a minimum of expense. There was an added burden on the regulations-setting process, the limited license drawing process, the enforcement effort, and administration, mostly in personnel time. However, this increased burden was relatively minor and did not require the hiring of any additional employees. Instead, the workload was distributed among existing personnel.

A specified budget was not required to administer, monitor or evaluate the experimental Wildlife Ranching Program. The only "added" costs associated with the program were for some vehicle mileage, per diem, telephone, and postage expenses estimated to total not more than $5,000 for the 3 years, and these were absorbed by existing budgets.

The program coordinator spent approximately 10-15% of his time administering the program during the third year (1988), with most of the increased time being required to prepare the evaluation of the program.

CONCLUSIONS AND RECOMMENDATIONS

The 3-year experimental Wildlife Ranching Program was a test of a unique approach to the cooperative management of wildlife on private lands. It opened nearly 800,000 acres of private land on 10 ranches to public hunting where little or none existed before 1986. Almost 2,100 private and public hunters harvested 1,657 animals of 6 species, with success rates in excess of those obtained during statewide rifle season. Hunter participation and harvest figures would have been even higher had all 10 ranches been under the program for the entire 3-year experiment. The program protected some valuable wildlife habitat by stopping, or at least delaying, plans to further subdivide 1 of the ranches. these results suggest that overall the program produced substantial benefits in public access, quality hunting, habitat protection, and greater DOW flexibility in managing wildlife populations on private lands.

Administratively the program was judged to be feasible. Expenses were minimal and few procedural and difficulties occurred among the program coordinator, DOW personnel at the administrative and field levels, and private landowners. The program ran amazingly smooth considering the number of individuals involved in the process.

While the overall program generated substantial public benefits, these benefits varied considerably among the 10 experimental ranches. The public received relatively few licenses on some ranches, raising the question of viability of the program on these ranches. The DOW simply cannot afford the time and effort required to administer a program with minimal

public benefits. The discussion of issues in the previous section provide the major arguments on this subject. Specific guidelines must be developed that address these issues if the Wildlife Ranching Program is to continue.

The potential exists for the Wildlife Ranching Program to provide major statewide benefits to private landowners, the public, and the business community. It cannot prosper without long-term public support. This support will depend on the credibility established by the DOW and ranches in developing and conducting a fair program.

Based on results of the evaluation of the 3-year experimental program, it is recommended that the Wildlife Commission continue and expand the Wildlife Ranching Program on an operational basis. Owners of the 10 experimental ranches prefer continuation of the program in its present form. However, the DOW, with public support, feels some adjustments are necessary to better balance private and public benefits.

FOOD HABITS OF THE PRONGHORN

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Abstract: More than 200 studies of pronghorn food habits have been reported in literature. I have selected 21 of these to characterize the feeding patterns of pronghorns. These studies present the percentages of grasses, forbs, and shrubs consumed, present estimate of forage available to pronghorns, and calculate preference ratings. Nine of the studies were conducted in grassland, 11 in shrub-steppe, and 1 in desert biomes. For all biomes, grass was the least preferred forage class, having a preference rating of 0. Forbs consistently had the highest preference rating, often exceeding that of shrubs 3-fold. Pronghorns prefer many plant species noxious to livestock. They consume less than one percent of forage produced on western rangelands today. For better understanding and management, there is a need for laboratory research to determine the nutritional requirements of pronghorns.

INTRODUCTION

There have been more than 200 food habit studies conducted on pronghorns during the past 50 years. Sundstrom el al. (1973) reviewed 140 studies in Canada and the United States. Yoakum and Spalinger (1979) in their compilation of papers on pronghorns in the first 40 years of the Journal of Wildlife Management, found there were more articles on food habits than any other subject.

Food habit studies of pronghorns have been conducted using various methods, including direct observations, indirect observations, stomach analyses, fecal analyses, and cafeteria trials. Some studies lasted a month or so; others lasted one or two seasons of the year; still others were year-long or longer. Some studies collected forage availability data, but most did not. Analyses of findings also were reported in various methods. These various procedures for collecting, analyzing, and reporting results of food habit studies all had advantages and disadvantages; however, the nature of their differences made them not always comparable. This latter point was not often recognized in early studies, leading to some comparisons that were misleading and not representative of pronghorns diet or preference. Consequently, the objective of this paper was to review published reports of pronghorn food habits with similar and comparable techniques.

METHODS

Published food habit reports were reviewed, and those meeting the following criteria were compared:

1. Diet selection samples were collected year-long.

2. Percent composition of diet was reported for grasses, forbs, and shrubs. All plants were placed in one of these classes. Cacti and half-shrubs were included as forbs by most investigators. Results were recomputed for those reports that did not.

3. Percent composition of available vegetation by forage class was provided.

With the above information, it was possible to determine forage preference ratings using the formula: PR = D/R (Krueger 1972) where D is the percentage of the pronghorn diet composed of a forage class and R is the percentage of the total forage available for the same forage class. Plants with ratings more than one were considered preferred.

This information provided data on what plants were available to eat, what plants pronghorns actually ate, and allowed rating of pronghorn preference for forage classes. This information can be used for selection of transplant sites, determining plant species for forage allocations, listing plants preferred by pronghorns in rangeland plantings, and evaluating competition with other wild and domestic herbivores.

The various studies were segregated into the three biomes presently occupied by pronghorns: grassland, shrub-steppe, and deserts. Sorting the studies into biomes with similar plant communities made comparisons of use of forage classes more meaningful.

No attempt was made to evaluate nutritional needs of pronghorns because the review of literature disclosed no report identifying nutritional requirements of pronghorns based on laboratory research.

RESULTS

Of the food habit studies reviewed, 21 contained sufficient data for this study. The results for each study were tabulated by biome as follows.

Grassland Biome: The grasslands contain the largest number (66 percent) of pronghorns living in modern times (Yoakum 1972, Sundstrom et al. 1973). Grasslands extend from the most northern occupied rangelands in Saskatchewan, Canada, south through the

Great Plains of the United States, to the alta-plateau of central Mexico - by far the most extensive biome used by contemporary pronghorns.

Nine studies represent the grasslands: one in Canada, seven in the United States, and one in Mexico (Table 1). Most of these were conducted during the last decade. The average percent composition of available forage was 71 for grasses, 18 for forbs, and 11 for shrubs. Average composition of diets was 14 percent grasses, 67 percent forbs, and 16 percent shrubs (Figure 1). Based on these figures, the mean preference ratings were 0.2 for grasses, 3.8 for forbs, and 1.4 for shrubs. Grass was available during all seasons, but by choice, was not ingested frequently. Forbs were readily consumed in all seasons with greatest utilization in spring and summer. Some forb use continued into winter. Shrubs also were used during all seasons, but they were used more when forbs were not available. Preference was four times greater for forbs than shrubs on a year-long basis for all studies in the biome.

Table 1. Food habits of pronghorns in the grassland biome.

Study Site	Reference	Forage Class	Percent Composition of Vegetation	Percent Composition of Diet	Preference Rating
Newell, Alberta	Mitchell & Smoliak 1971	Grasses	78	13	0.2
		Forbs	21	51	2.4
		Shrubs	3	35	11.7
National Bison Range, MT	O'Gara & Greer 1970	Grasses	79	15	0.2
		Forbs	7	67	9.6
		Shrubs	14	18	1.3
Pawnee Grasslands, CO	Schwartz & Nagy 1976	Grasses	55	49	0.9
		Forbs	5	45	9.0
		Shrubs	40	4	0.1
Shortgrass Prairies, KA	Hlavachik 1968	Grasses	92	27	0.2
		Forbs	4	76	19.0
		Shrubs	3	2	0.5
	Sexson 1979	Grasses	94	46	0.5
		Forbs	5	48	9.2
		Shrubs	0.2	6	30.0
Shortgrass Prairies, NM	Russell 1964	Grasses	71	4	0.1
		Forbs	18	70	3.9
		Shrubs	11	26	2.4
Roswell, NM	Howard et al. 1983	Grasses	94	3	0.0
		Forbs	1	71	70.4
		Shrubs	5	26	5.3
Panhandle, TX	Roebuck 1982	Grasses	68	1	0.0
		Forbs	24	82	3.5
		Shrubs	8	13	1.5
Chihuahua, Mexico	Habit de Pena & Pena Neira 1982	Grasses	33	2	0.0
		Forbs	62	75	1.2
		Shrubs	5	6	1.2
AVERAGE		Grasses	71	14	0.2
		Forbs	18	67	3.8
		Shrubs	11	16	1.4

Shrub-steppe Biome: All food habit studies in shrubland communities were completed in the United States, in Montana, Idaho, Oregon, California, Utah, Colorado, Nevada, New Mexico, and Texas. Studies were completed during the last 40 years with the majority completed more than 20 years ago.

Eleven studies were compared for the shrub-steppes (Table 2). The average percent composition of forage available was 37

Table 2. Food habits of pronghorns in the shrub-steppe biome.

Study Site	Reference	Forage Class	Percent Composition of Vegetation	Percent Composition of Diet	Preference Rating
Yellow Water Triangle, MT	Cole & Wilkins 1958	Grasses	44	9	0.2
		Forbs	13	23	1.8
		Shrubs	43	68	1.6
Red Desert, WY	Severson et al. 1968	Grasses	38	5	0.1
		Forbs	15	9	0.6
		Shrubs	47	78	1.6
Rawlins, WY	Taylor 1975	Grasses	74.5	4	0.0
		Forbs	0.4	15	37.5
		Shrubs	25.1	81	3.2
Northwest Shrub-Steppes CO	Bear et al. 1972	Grasses	32	1	0.0
		Forbs	15	42	2.8
		Shrubs	53	56	1.1
Trickle Mountain, CO	Bailey & Cooperrider 1982	Grasses	27	4	0.1
		Forbs	48	18	0.4
		Shrubs	25	78	3.1
Panhandle, TX	Roebuck 1982	Grasses	50	4	0.0
		Forbs	12	70	5.8
		Shrubs	38	20	0.5
Little Lost-Birch Creek ID	McCarty 1982	Grasses	30	2	0.0
		Forbs	6	18	3.0
		Shrubs	64	80	1.3
Hart Mountain, OR	Mason 1952	Grasses	5	2	0.4
		Forbs	10	31	3.1
		Shrubs	85	67	0.8
Drakes Flat, OR	Yoakum 1957	Grasses	28	21	0.8
		Forbs	10	25	2.5
		Shrubs	62	54	0.8
Sheldon National Wildlife Refuge, NV	Hansen 1986	Grasses	22	5	0.2
		Forbs	20	46	2.3
		Shrubs	58	45	0.8
Adobe Valley, CA	Goldsmith 1988	Grasses	61	17	0.2
		Forbs	11	16	1.5
		Shrubs	28	67	2.4
AVERAGE		Grasses	37	7	0.2
		Forbs	15	29	5.6
		Shrubs	48	63	1.6

for grasses, 15 for forbs, and 48 for shrubs. Percent composition of diets averaged 7 for grasses, 29 for forbs, and 63 for shrubs (Figure 1). Forage preferences averaged 0.2 for

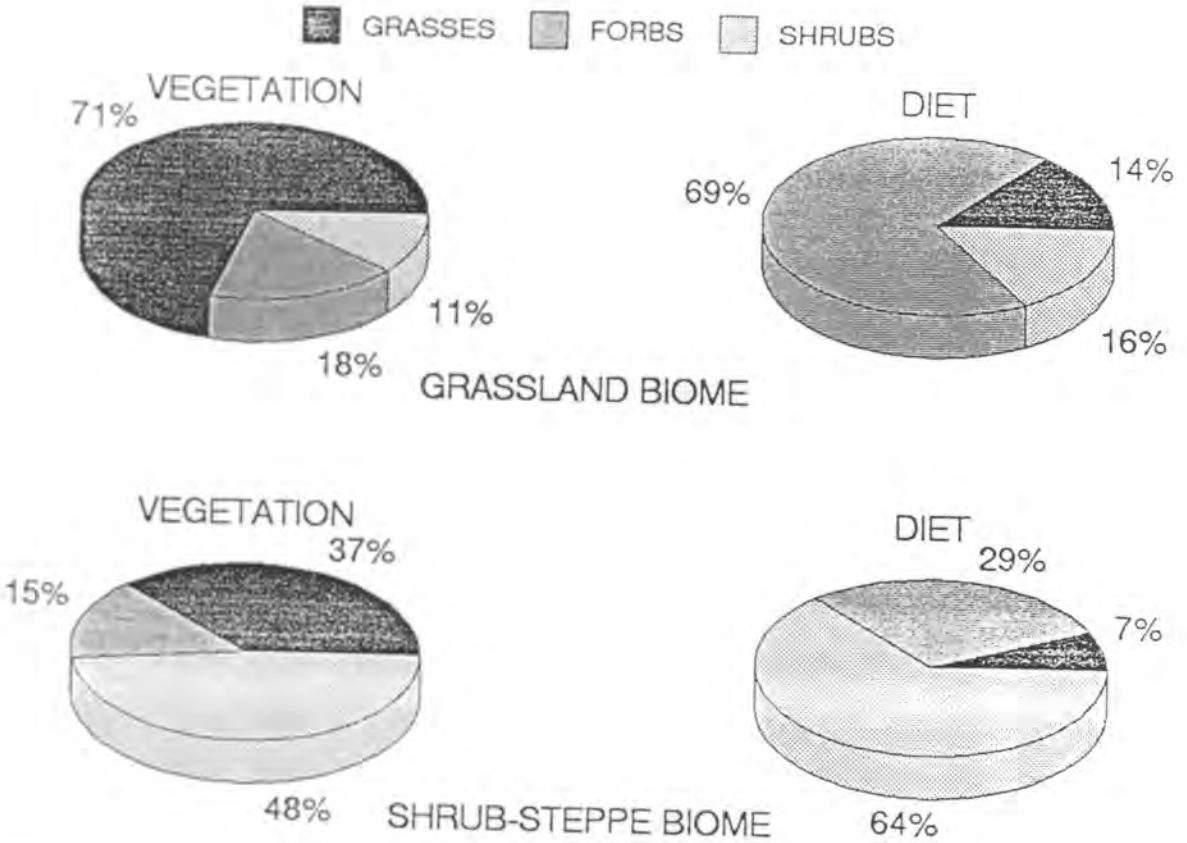

Figure 1. Comparison of available vegetation on pronghorn rangeland and diet selection.

grasses, 5.6 for forbs and 1.6 for shrubs. It is noteworthy that even in shrublands, pronghorn preferences for forbs was almost 3-fold greater than for shrubs. Grasses were consumed primarily during spring and summer when most available. Shrubs were used during all seasons with greatest consumption during fall and winter.

It is uncertain how much heavy grazing of forbs by livestock on poorer rangelands alters pronghorn diet. Heavy use of forbs and grasses by livestock over several years may change vegetative composition and make preferred forbs less available to pronghorns (Wager 1978).

Desert Biome: Only one report was located for the desert biome: the Sonoran desert in Arizona and Mexico (Arizona Game & Fish Dep. 1981). A study for the Vizcaino Desert in South Lower California was not located in time to include in this report.

For the Sonoran desert study, the year-long diet selection from 1974-78 averaged 0.4 percent grasses, 75.5 percent forbs, and 22.4 percent shrubs. Forbs were consumed in greater quantities than shrubs in all months except January. No information was provided relative to composition of forage availability.

DISCUSSION

Results of many early pronghorn diet studies were not representative of year-long patterns because most samples were obtained from hunters in the fall in the shrub-steppe biome. This frequently resulted in concluding that pronghorns, by choice, preferred shrubs. Recent studies using preference ratios based on concurrent data for available forage and diet selection, indicate pronghorns are, by choice, first grazers of forbs, next browsers of shrubs, and consumers of grass in small quantities. This preference for forage classes clearly exists in grassland and shrub-steppe and probably in desert, although insufficient information is available for the desert.

It is now apparent pronghorns are not major consumers of grasses. They do eat grasses at all seasons in all ecosystems, however, total consumption rarely exceeds 10 percent of the year-long diet. In some areas, and especially in the spring, grasses are a favored and nutritious forage. Therefore, all quality pronghorn habitat will provide grasses for forage. Both dry and green grasses are consumed, but finer textured grasses are favored over coarse grasses. Preference ratios for grasses rarely exceed 0.5 throughout the pronghorn range.

Forbs were the most preferred forage class whenever available. Consumption of forbs greatly exceeded that of shrubs, and forb preference ratios likewise exceeded shrubs in all biomes. Forbs are often succulent and high in nutrients. The use of forbs has been linked to pronghorns production and survival (Ellis and Travis 1975, Howard et al. 1983). The lack of forbs in certain areas has been attributed to competition with livestock (Autenrieth 1984, Pyrah 1987, Howard et al. 1983). Forb species noxious to livestock were consumed frequently with no apparent ill effects to pronghorns. Some rangelands contained more than 150 forb species, of which 80 to 90 were eaten by pronghorns. However, 5 to 10 species usually comprised the bulk of the diet.

Results of this review emphasize that managers need to recognize the importance of forbs in habitat management for pronghorns. When livestock grazing systems are developed, considerations should be given to forbs as key species. Phenological considerations are especially important. Many forbs do not seed until a month or longer after grasses. Forbs should be included in seeding mixes used in range rehabilitation

projects. Because pronghorns consume a wide variety of forbs, the availability of many native forb species will improve habitat quality. The high values of succulence and nutritive content of forbs benefit pronghorns and other wildlife.

Shrubs also provide important pronghorn forage. Many species of shrubs are readily consumed at all seasons of the year, especially the low-growing sagebrushes. In some shrub communities, browse is heavily used, especially during fall and winter. Shrubs are frequently termed "survival forage", for they often are available above deep snows when other forage is not available. Studies have shown that bitterbrush, sagebrush and other shrubs provide important sources of protein and other nutrients.

Unfortunately, there is little information available on the nutritional requirements of pronghorns. A review of the literature found no reports of detailed laboratory research conducted to determine the nutritional requirements of pronghorns. This absence of basic biological information severely hampers managers in assessing pronghorn requirements, or while attempting to apply forage allocations for pronghorns on rangelands commonly used with other herbivores. Such information is especially important as Stoszek et al. (1980) have shown low fawn recruitment in areas low in certain trace elements. Here is an area of special challenge to future pronghorn researchers.

Our knowledge of contemporary pronghorn food habits provides information of interest and value. Pronghorns consume less than one percent of the forage produced on western rangelands today. They do not compete for forage with cattle or horses except on rangelands in poor condition; however, forage competition can exist with domestic sheep as both prefer forbs and shrubs (Yoakum and O'Gara 1990). Plants highly noxious to livestock are often eaten in large quantities by pronghorns with rare cases of toxicity.

Acknowledgements: Appreciation is extended to Bart O'Gara, Jack Richardson, Marshall White and Tom Pojar for reviewing the original manuscript and providing many suggestions that were incorporated.

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HARVEST MANAGEMENT OPTIONS FOR A PIONEERING PRONGHORN POPULATION

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Abstract: Management of a pioneering population that is re-inhabiting what could prove to be prime historic range presents some unique management situations. The major question is what is the carrying capacity of this "re-established" range. Accurate estimates of population size and herd structure facilitated by radio collared animals allows calculation of rate of increase and projections of the K-value. Management options drawing on population dynamics theory are explored.

INTRODUCTION

Since at least 1911, pronghorns (Antilocapra americana) have been protected from hunting in Middle Park (MP), Colorado (Feltner 1972). That is not to say that pronghorns never have been hunted in MP. During the market hunting era of the late 1800's, pronghorns were taken to help fill tonnage quotas of market hunters supplying nearby booming mining camps. Market hunters preferred elk (Cervus elaphus), bighorn sheep (Ovis canadensis), and mule deer (Odocoileus hemionus) because quotas could be filled with fewer carcasses. However, from the diary of one hunter, Frank H. Mayer, (Roth 1963) it was apparent that pronghorns were readily available and were relied upon to finish filling wagon loads just prior to shipping. According to Mayer's diary, "Antelope are constantly in evidence." (Roth 1963:32) and he tells of seeing groups of 100-200 head during late summer. We estimate from tonnage records in his diary that he killed approximately 81 pronghorns between 2 August and 30 September in the year of 1878.

Middle Park pronghorn populations were in rapid decline by as early as 1879 (Black 1969). Expansion of the livestock industry in 1882 and the arrival of the railroad to Kremmling in 1906 (Cairns 1975), both contributed to the near extirpation of MP pronghorns by the 1920's.

Concern that pronghorns might become extinct prompted a nationwide survey by the Biological Survey (U.S. Department of Agriculture) during 1922-1924 to estimate the numbers of pronghorns in an effort "...to form a basis on which intelligent conservation measures might be built.." (Nelson 1925:22). A total of 1233 pronghorns distributed over 28 areas were counted in Colorado during 1923 and the report for MP is as follows: "In Middle Park, northwestern Grand County, a small band of 7 still exists. This was formerly a favorite range for antelope, but they have been rapidly decreasing there and will probably be

completely exterminated in the not distant future." (Nelson 1925:28).

This ominous prediction came to fruition almost before the ink dried. There were no reported sightings of pronghorns in MP for the next 50+ years. However, beginning in the early 1970's, pronghorn sightings were reported with increasing frequency. The largest number sighted since the report of 7 pronghorns in 1923 was on 21 August 1979 when a group of 13 were seen 10 miles north of Kremmling in the area of Antelope Pass (RBG). Rare as they were, early sightings were always during summer and it was not until the winter of 1983-84 that it was verified that pronghorns wintered in MP.

The winter of 1983-84 was extremely severe in MP. This was one of the occasional severe winters during which about 50 percent of the mule deer population perished even with some supplemental feeding (Carpenter et al. 1984). A group of 28 pronghorns survived this winter on a wind swept ridge 4-5 miles northeast of Kremmling. Even with no supplemental feed there was no detectable mortality in this group. This provided the first concrete reminder that MP possessed a viable yearlong niche for this species.

The MP pronghorn survived a moderately severe winter in 1988-89 again with no detectable mortality. The population at this time was 122 and they wintered in the same general area as in 1983-84. Their wintering area was about 7 square miles in size. During this winter mule deer mortality was about 30 percent.

Middle Park was apparently overlooked as a transplant site for pronghorns during the early years of pronghorn management which emphasized trapping and transplanting. As with most areas of the state of Colorado, the mule deer population was expanding and in MP managers were concerned that pronghorns and mule deer would compete for limited winter range. It is assumed that the pioneering population that now inhabits MP came from North Park via Muddy Pass which is a relatively low and open pass joining North Park and Middle Park.

Management of a pioneering population that is re-inhabiting what could prove to be prime historic range presents some unique management situations. The major question is what is the carrying capacity of this "re-established" range (i.e. the K-value for the population)? How soon should a harvest be considered and at what level? In this paper we review some of the management options considered for this population and examine the possible consequences of each.

METHODS

A portion of the population was trapped on 2 occasions, once in December 1986 (47 animals) and again in December 1988 (67 animals). Nine radio collars were deployed during the first trapping and 20 more during the second. Some radios were replaced during the second trapping and with some radio failures and animal mortality, there are 20 viable radios at this time (Spring 1990). All animals trapped were marked with either a radio, plastic numbered collar, and/or a numbered ear tag.

Trapping and handling procedures followed those sanctioned by the Pronghorn Antelope Workshop (Anonymous 1984). Of the 114 animals trapped, there were no injuries or fatalities. All marked animals were observed at least once post-trapping indicating that there was no latent mortality due to the stress of the trapping operation.

The radioed pronghorns were located biweekly (with very few exceptions) since 1 January 1987. Tracking was done mostly from the ground to increase the probability of observing and identifying animals with numbered plastic collars. Fixed wing aircraft was used if an animal could not be located after reasonable effort from the ground. Legal descriptions of animal locations were recorded to the nearest quarter mile then converted to UTM's (U.S. Army 1973) coordinates for computer processing.

During late summer and fall all animals accompanying the radioed pronghorn were counted and classified by sex and age. Herd structure estimates used in the following analysis were based on the classification with the largest sample size. The exception to this is the herd structure estimate for the fall of 1986 which was based on the sample of 47 animals trapped on 16 December 1986.

The population size estimates were made during winter when the population was concentrated on the wintering area. It was assumed that counts of all animals accompanying the radioed animals at this time of year yielded a total count of the population. It was possible to get an accurate total count in each group (sometimes the animals were all in one group) and it was also possible to count the number of bucks that were 1 1/2 years old and older as a check on the earlier herd structure estimate.

RESULTS

Early growth patterns of the MP pronghorn population have mimicked the early stages of the theoretical sigmoid growth curve (Figure 1). It took from 1979 until 1984 for the population to double the first time. It doubled again over the next 2 years.

Population estimates since deployment of radio transmitter collars (1986-87) are considered to be accurate and have been used to calculate the population's rate of increase. The rate of increase (N_2-N_1/N_1) for the past 3 years provides a minimally meager data set upon which to estimate a regression on population size and project a K-value for this population (Figure 2). Figure 2 is based on the following observed values:

Year	Pop. Size	Rate of Increase
1986-87	80	--
1987-88	122	.52
1988-89	160	.31
1989-90	223	.39

Using the regression equation from Figure 2, an estimated K-value for the population is 624 animals. This is key information for formulating long range management plans but must be used with caution since the regression is based on only 3 points.

There are 2 major situations that could drastically alter the above relationship. It is possible that as a wider range of climatic (i.e. winter) conditions are manifest in the data set, the populations' response to density may be overshadowed by its response to climatic conditions. In this case, the rate of increase relationship with density would become indiscernible among environmental "noise" and would not provide us with a good projection for the K-value. At this point, management objectives would have to be tied to some arbitrary decision regarding projected population density potential.

A second contingency that could affect the rate of increase and, therefore, the K-value projection, is continued pioneering of the population into other parts of MP. Fragmenting of the wintering herd could release much more potential for growth than current projections indicate.

Due to the gregarious nature of this species, it was possible to classify one-half to three-fourths of the population by classifying all animals that accompanied radioed animals. Even with only 5.7 percent of the population radioed (1987), the herd structure sample was 52 percent of the population (Table 1).

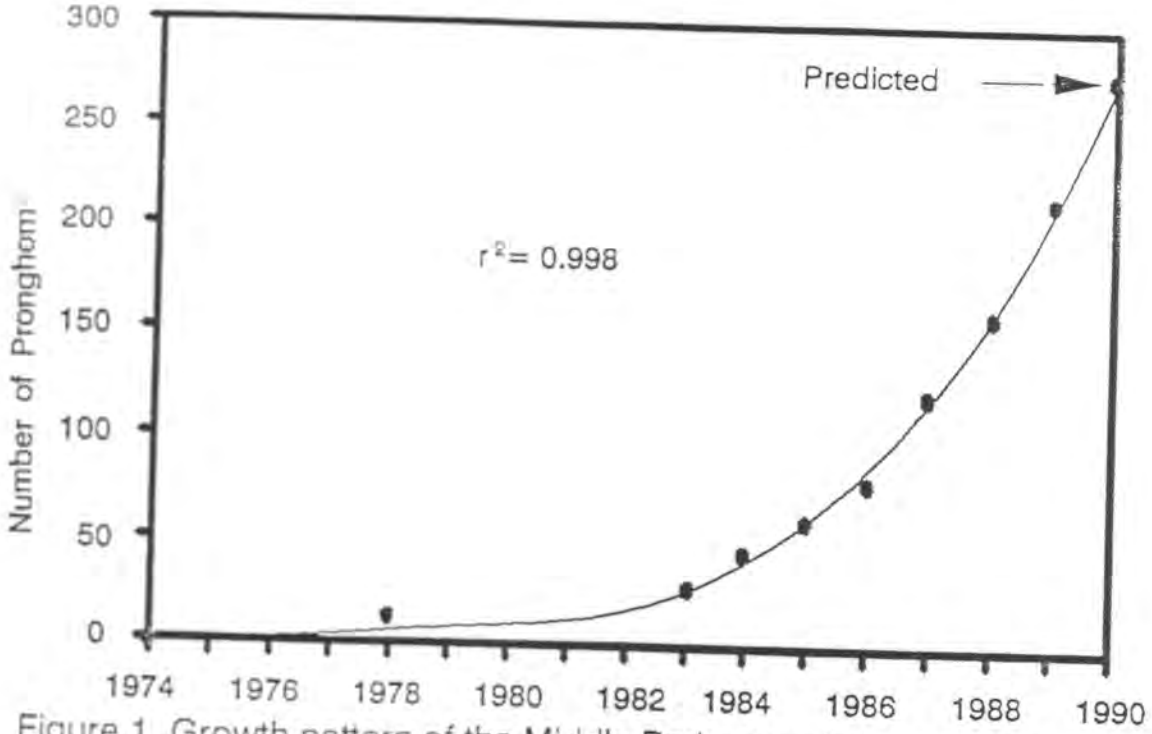

Figure 1. Growth pattern of the Middle Park pronghorn population from 1974 through 1990.

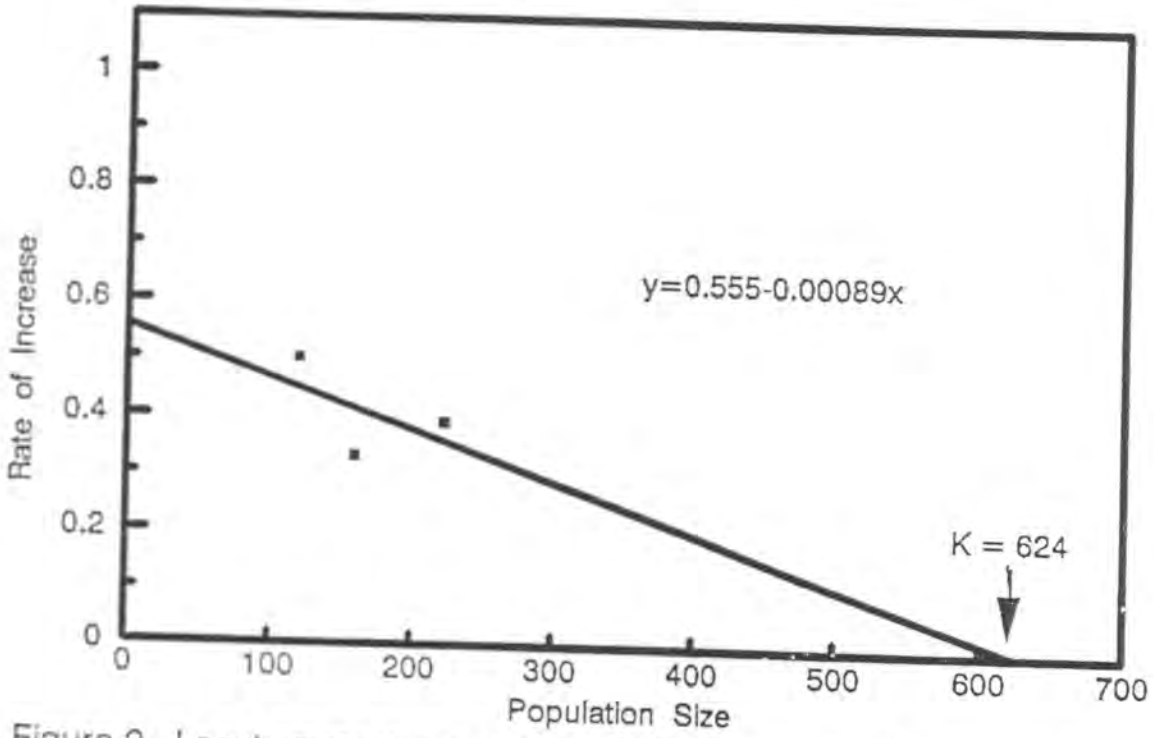

Figure 2. Least squares regression of observed rate of increase for the Middle Park pronghorn population, 1987-89.

Table 1. Herd structure based on sample obtained by locating radioed animals.

YEAR	POP. SIZE	NO. RADIO	% RADIO	B:D RATIO	F:D RATIO	SAM-PLE	% OF POP.
1986[1]	80	--	--	36	77	47	59
1987	122	7	5.7	54	77	63	52
1988	160	24	15.0	40	32	108	68
1989	223	22	10.2	56	50	161	72

[1] This year's data based on the sample of the population trapped 16 December 1986.

MANAGEMENT OPTIONS

With the above basic population information it is possible to make some projections and begin to consider some management options for this population. At this point it seems prudent to play the management game in an ultra conservative fashion. We have limited experience with this population and have observed its response over a limited range of climatic conditions. It is possible that as the population grows toward K, the density and rate of increase may become more unstable due to the range of climatic conditions that can occur. Severe winter conditions may have a greater impact on a larger population than the recent severe winters have had on the relatively small population.

The ultimate objective of a management plan is to be "safe" with the primary product being preservation of the resource and, secondarily, utilization of the resource to maximize recreation. Other factors to consider are competition with livestock and other game species and crop depredation.

Limit Population Expansion

One obvious option is that just a token pronghorn population should be maintained in MP. A population of 200-300 animals might be considered "token". This would minimize any possible conflicts with private landowners and competition with other wild ungulates (if there is any) would be negligible.

The projected population size for fall 1990 is about 300 animals. It appears from Figure 1 that this population size may be near the maximum growth rate and, therefore, near the size where maximum sustained yield (MSY) would be realized. Assuming that the K-value approximates 600 animals and using some crude

estimations suggested by Caughley (1977), a harvest of 66 animals annually would maintain the population at MSY, or 300 animals.

A fallacy of this approach is that these 66 animals would have to be removed in proportion to all age classes and both sexes that are present in the population - not an easy thing to do. A second fallacy to this simplistic approach is that the calculated K-value (and MSY density) is predicated on the assumption that the environment does not fluctuate from year to year. This, of course, is not the case. Environmental fluctuation results in changes in survival, fecundity, age distribution, and rate of increase. In other words Mother Nature will never allow us to lock onto a constant K-value.

McCullough (1979) provides an excellent discussion of the consequences of managing a population above or below the MSY density. In our example we would be attempting to manage at or below MSY. Attempting to manage at this level, from a manager's perspective, is like walking into a mine field - something bad is likely to happen. Here are the reasons.

The worst thing that can happen is that over harvest for only a few years will cause the population to go extinct. This is because the harvest removes the "surplus" and a portion of the base population. Next, the population's response to either under or over harvest tends to compound the effect and makes drastic adjustments in subsequent harvests necessary to compensate.

Under harvest allows the base population to increase which also increases recruitment. The subsequent harvest, then, must be increased to remove the additional animals in the base population <u>and</u> the increase in recruitment. Over harvest, on the other hand, works in just the opposite direction. Reduction of the base segment of the population also reduces recruitment. The next harvest must be reduced to accommodate recovery of the base population. Additional excitement is added to this approach by constantly fluctuating environmental conditions that alter the MSY density level independent of harvest and these changes must also taken into account in setting subsequent harvests.

Management at or below MSY is possible with adequate monitoring of key population parameters. However, the manager and the interested publics must be aware that the harvest may fluctuate widely from year to year giving the impression of "boom and bust" management.

<u>Unlimited Population Expansion</u>

A very reasonable, but possibly unrealistic, management option to apply to a pioneering population would be no harvest until the K-value is determined. This strategy has the distinct advantage of allowing the managers to obtain a good estimate of

the populations' potential. In MP the present population occupies only about one-third of the sagebrush steppe habitat available. Increased density in the currently occupied range may be the impetus to further pioneering in MP and the K-value of 600 animals may be a gross underestimate the true value for MP.

The "no harvest" strategy also offers the managers a haven from the stinging criticism that premature harvesting of the population caused it to go extinct. The population is large enough now that it should be fairly robust to severe winters. However, the herd still winters as essentially one group and it is conceivable that treacherous localized conditions may allow few, if any, survivors. The herd will be susceptible to such a catastrophe until (and if) it splinters into distinctly separate wintering groups.

With increased numbers of pronghorns in MP, there is increased pressure from livestock interests and sportsmen to open a hunting season. Populations of mule deer and elk are at all-time highs in MP and landowners see pronghorns as just another source of competition for livestock. Pronghorns are highly visible and local sportsmen and guides see increased numbers of pronghorns and a few trophy-sized bucks and believe the resource is being "wasted" if it is not hunted. Therefore, there is pressure to conduct a hunting season on the MP pronghorn population.

Compromise Management

Although minor risks are involved, a healthy, growing population of 300 animals should be capable of sustaining some harvest. After considering a full range of management options and holding public meetings a "research" alternative was selected (Byrne 1990). This alternative calls for a limited harvest of 10 to 15 animals per year for the next 2 years. And in fact for the 1990 hunting season there will be 10 buck and 5 doe/fawn permits issued. This satisfies the requests for at least having a hunting season yet removes so few animals (c.a. 5% of the population) that the growth toward K is not significantly inhibited.

With the number of permits set for 1990 and some solid information on the rate of increase for the past 3 years, we now have data for making some long term projections. The growth pattern was projected through K population size (Figure 3) using the observed rate of increase relation in Figure 2. Carrying the assumed harvest of 15 animals in 1990 through subsequent years, the growth curve is projected in Figure 3 to demonstrate its effect as the population moves towards K both with and without harvest.

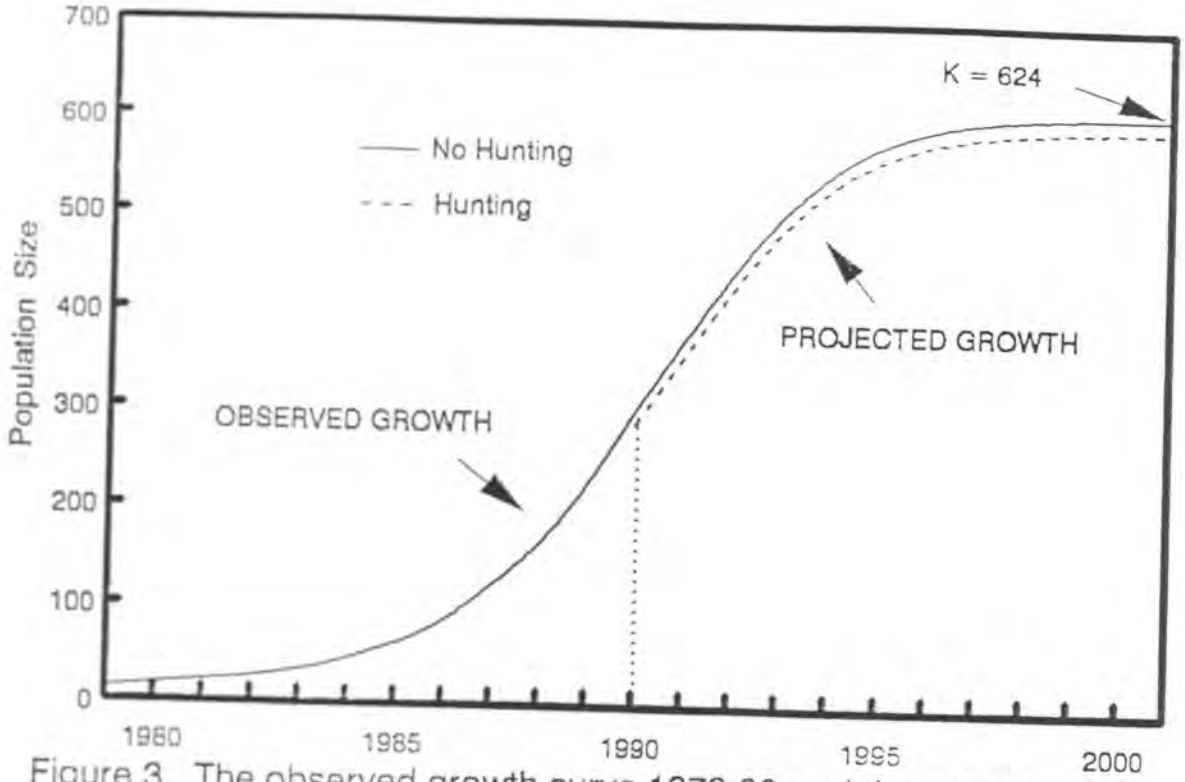

Figure 3. The observed growth curve 1979-90 and the projected growth 1991-2001 with no hunting and with an annual harvest of 10 bucks, 4 does and 1 fawn.

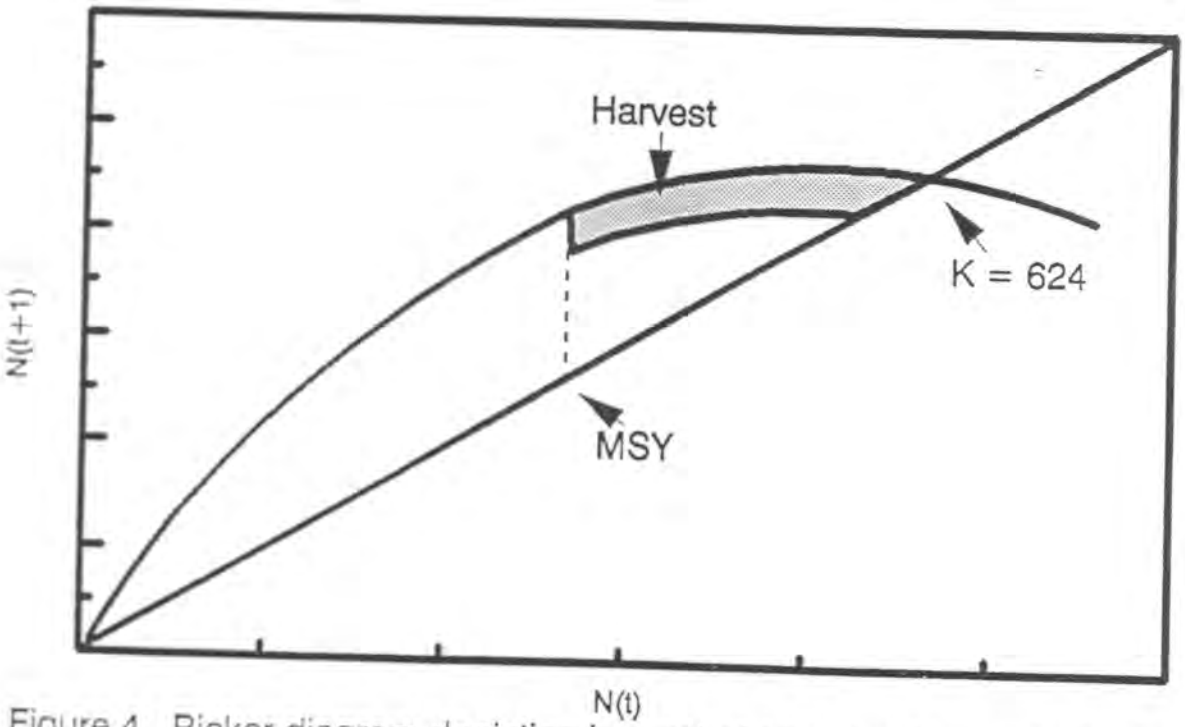

Figure 4. Ricker diagram depicting harvest of 15 animals annually. The ending population with harvest is 609.

The projected population size for fall of 1990 is near the calculated MSY of the Ricker scale in Figure 4. The harvest of 15 animals per year demonstrates that the "stable" population size is 15 animals less than K.

The calculated K-value is based on only 3 observed points of rate of increase which means that this value must be viewed with great caution. However, the relatively light harvest, if continued over the next few years, will not obscure the natural population growth and will permit continued observation of the affect of population growth on rate of increase. This in turn will allow the calculation of a much more reliable K-value. A reliable K-value is critical for estimating MSY and for setting long-term population objectives that maximize the benefits from this resource.

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BUSINESS MEETING

BUSINESS MEETING
14TH PRONGHORN ANTELOPE WORKSHOP

SilverCreek, Colorado
May 24, 1990

The business meeting was called to order by Chairman Tom Pojar at 9:00 a.m.

Delegates were present from Arizona, Colorado, Kansas, Montana, Nevada, Oregon, South Dakota, Texas, and Wyoming. A complete list of participants and their affiliation is as follows.

Thomas M. Pojar	Colorado
Richard Ockenfels	Arizona
Jim Yoakum	Nevada-BLM
Mitch Willis	Oregon
Walt Van Dyke	Oregon
Phil Riddle	Wyoming
Ray Lee	Arizona
Jennifer Slater	Colorado
Keith Sexson	Kansas
Danny A. Swepston	Texas
John Werde	South Dakota
Brian Czech	Arizona-San Carlos Apache Tribe
Bart O'Gara	Montana-Coop Wildl. Res. Unit
Bob Watts	Montana

Old Business

1. Trapping and Translocation Guidelines

Bart O'Gara updated the group on the revision of the Trapping and Translocation Guidelines which he, Mitch Willis and Ray Lee agreed to review at the last workshop. He reported that the guidelines have been reviewed and updated and are ready to be published in this year's proceedings. He also suggested that all the guidelines that have been prepared thus far should be included in a separate publication.

2. Depredation Guidelines

No progress was made on these guidelines even though they were discussed at the last 2 workshops. The most recent status of this topic was that Arizona and Idaho were to send a copy of their state depredation guidelines to all state/province representatives for review. These were then to be discussed at the 14th workshop.

New Business

1. Update of Pronghorn Management Guidelines

Jim Yoakum moved to form a committee to update the original Pronghorn Antelope Guidelines printed in 1978 and to publish an updated set of Management Guidelines with all supplements. He also suggested that the publication be completed by the next workshop. The motion carried.

Bart O'Gara volunteered to chair the committee. The following assignments were made:

Census--Tom Pojar, Tom Christensen, Bruce Johnson and Fred Lindzey.

Range Improvements--Jim Yoakum.

Energy Development--Phil Riddle.

Habitat Evaluation--Richard Ockenfels and Phil Riddle.

If the publication is ready before the next workshop, Colorado will publish the Guidelines.

2. Status of Pronghorns in Mexico

Jim Yoakum discussed the status of pronghorn in Mexico. Based on recent census, there is cause for alarm as there are possibly less than 400 pronghorn remaining in Mexico. The reasons are varied and complex, but poaching, loss of habitat and an indifferent government may be major factors. As a group, we engaged in open discussion to explore actions that we could take to help reverse the downward trend of pronghorn in Mexico. We discussed the possibility of bringing the situation to the attention of the following conservation organizations: World Wildlife Fund, Wildlife Management Institute, U.S. Fish and Wildlife Service and the Nature Conservancy. Bart O'Gara suggested that we offer technical assistance to the government of Mexico to analyze the situation and make recommendations.

A motion was made and carried to draft a statement of concern by the Pronghorn Antelope Workshop delegates and distribute it to the above conservation organizations and possibly others. Jim Yoakum volunteered to draft the statement and have it reviewed by the following: Bart O'Gara, Ray Lee, Tom Pojar and others who wish to contribute.

3. Host state for the 15th Workshop (1992).

An invitation was extended by Doug Scott, representing Yellowstone National Park, to host the next workshop. However,

Jim Yoakum pointed out that our Bylaws do not provide for entities other than states or provinces to sponsor workshops. In view of this fact, Phil Riddle, of Wyoming, offered to host the 15th Pronghorn Antelope Workshop.

The meeting was adjourned at 11:00 a.m.